Agricultural Systems 109 (2012) 101–112

Contents lists available at SciVerse ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Improving irrigated rice production in the Senegal River Valley through experiential learning and innovation

Timothy J. Krupnik [a,b,*], Carol Shennan [b], William H. Settle [c], Matty Demont [d], Alassane B. Ndiaye [e,f], Jonne Rodenburg [g]

[a] International Wheat and Maize Improvement Center (CIMMYT), House 9. Road 2/2. Banini, Dhoka 1213, Bangladesh
[b] Environmental Studies, University of California, Santa Cruz, 1156 High St., Santa Cruz, CA 95064, USA
[c] FAO, Plant Production and Protection Division, Room B750, viale delle Terme di Caracalla, Rome, Italy
[d] Africa Rice Center (AfricaRice), Sahel Regional Station, BP 96 Saint-Louis, Senegal
[e] FAO, Programme Gestion Intégrée de la Production et des Déprédateurs, BP 3300 Dakar, Senegal
[f] Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du Fleuve Sénégal et des Vallées du Fleuve Sénégal et de la Falémé (SAED), BP 74 Saint-Louis, Senegal
[g] Africa Rice Center (AfricaRice), East and Southern Africa, P.O. Box 33581, Dar es Salaam, Tanzania

ARTICLE INFO

Article history:
Received 13 May 2011
Received in revised form 18 January 2012
Accepted 24 January 2012
Available online 18 April 2012

Keywords:
System of Rice Intensification
Best Management Practices
Water-saving
Weed management
Farmer Field School
Action research

ABSTRACT

Research facilitating farmer–researcher collaboration and experiential learning may provide the missing element to tailor crop management recommendations to meet farmers' needs. We tested different crop management systems for irrigated rice in three seasons of adaptive research trials in three locations in the middle Senegal River Valley. Our objectives were to assess the agronomic and socio-economic viability of Recommended Management Practices (RMPs) compared to the System of Rice Intensification (SRI) and Farmers' Practices (FPs). During the 2008 dry season, RMP and SRI significantly increased yields over FP by 2.3 and 2.6 t ha^{-1} across sites. Farmers analyzed their experiences in post-experiment meetings. They appreciated SRI's yield and water-saving potential, but found it labor demanding, especially for weed management requirements that coincided with horticultural activities. Conversely, farmers described RMP's elevated herbicide rate as costly, and indicated that because of poorly functioning agro-chemical markets, herbicide volumes larger than typically used in FP might be difficult to reliably source. To modify management systems to fit farmers' needs and assets, we collaboratively developed a fourth, 'Farmer Adapted Practice' (FAP) that blended RMP and SRI. FAP used intermittent irrigation during the late vegetative stage, recommended crop density, intermediate seedling age, and a single round of mechanical weeding followed by localized herbicide application. Farmers compared FAP against the initial management systems in the subsequent seasons. Though no yield differences were found between RMP, SRI and FAP, each yielded significantly more (+1.0, +1.1 and +1.5 t ha^{-1}) than FP. FAP also reduced labor requirements without increasing weed biomass compared to RMP or SRI, and used 40% and 10% less herbicide than RMP and FP, respectively. Cumulative distribution functions showed that FAP increased net profit potential and decreased economic risk. Prior to the 2009 dry season trials, the Senegalese state eliminated herbicide subsidies, doubling their cost. RMP, SRI and FAP yielded 2.9, 3.0 and 3.1 t ha^{-1} more than FP. FAP again reduced weeding labor and herbicide requirements while lowering production risk across sites. This study demonstrates the value-added outcomes that result from research that facilitates farmer–researcher collaboration to learn from, innovate and tailor management systems to fit local circumstances.

1. Introduction

Per-capita consumption of rice (*Oryza sativa* L. and *O. Glaberrima* Steud.) in the Sahelian nations of West Africa has doubled in the last 50 years (Balasubramanian et al., 2007), though production has failed to keep pace with demand. The majority of consumed rice is consequently imported from Asia, at a cost of nearly $1 billion in 2009 (FAOSTAT, 2012), draining foreign currency reserves and undermining regional food sovereignty (Seck et al., 2010). Following the Sahelian famines of the 1980s, 40,000 ha of irrigation schemes were constructed on the southern bank of the Senegal River to increase domestic rice production. Increased rice output is the primary goal of the Senegalese GOANA program (*Grande Offensive Agricole pour la Nourriture et l'Abondance*), launched in 2008, that aims to reduce imports and achieve national food self-sufficiency by 2015. However, farmers' yields in the Senegal River Valley

* Corresponding author at: CIMMYT-Bangladesh. House 9. Road 2/2. Banini, Dhaka 1213, Bangladesh. Tel.: +880 2 989 6676,X12.
E-mail addresses: t.krupnik@cgiar.org (T.J. Krupnik), c.shennan@ucsc.edu (C. Shennan), william.settle@fao.org (W.H. Settle), m.demont@cgiar.org (M. Demont), bounandiayepodor@gmail.com (A.B. Ndiaye), j.rodenburg@cgiar.org (J. Rodenburg).

0308-521X/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.agsy.2012.01.008

(SRV) remain lower than anticipated, and are constrained by a number of linked agronomic and socioeconomic factors. While fertilizer and herbicide use can be profitable (Haefele et al., 2000), imperfect crediting systems limit farmers' timely access to sufficient inputs (Poussin, 1997). Irrigation fees are also pegged to diesel costs, which have risen dramatically since 2002 (MEB, 2009). Combined with limited support for the agricultural sector, these factors undermine rice farmers' production incentives (Seck et al., 2010). Rice crop management strategies that generate high yields while making more efficient use of available inputs may therefore provide an alternative pathway to increase rice production in the SRV.

One widely promoted alternative is the System of Rice Intensification (SRI). SRI is comprised of six management components including transplanting of (1) single, (2) young seedlings at (3) wide spacing, (4) alternate wetting and drying (AWD) irrigation, (5) mechanical weed control and (6) the application of organic matter in place of, or in addition to, chemical fertilizers. SRI's proponents argue these techniques result in high yields while reducing costly water and agrochemical requirements (Uphoff et al., 2010). With support ranging from the World Bank to civil society organizations, SRI is promoted in 15 sub-Saharan nations and another 33 globally (CIIFAD, 2012). In the Sahel, interest in SRI has increased following reports of large yield and profit gains in Mali (Styger et al., 2011a), though in Senegal, where SRI comprises a study subject in FAO-backed Farmer Field Schools, independent evaluation is lacking.

SRI's popularity, however, has been equally matched with controversy. Using meta-analysis, McDonald et al. (2006) found that SRI's benefits were limited when compared to recommended "best management practices". Uphoff et al. (2008) countered that such arguments were "academic" and "out-of-context" because resource-poor farmers, for whom SRI was designed, cannot typically afford the inputs recommended for best management. They further suggested that for such comparisons to be relevant, SRI should be treated as a flexible management system to be adapted to local circumstances. SRI's advocates, however, have also argued the opposite by employing terminology that describes SRI as a relatively fixed technological package (for discussion, see Glover, 2010). For example, Uphoff et al. (2008) dismissed McDonald et al. (2006) because they used data from experiments that did not strictly implement all six SRI management practices, which at times yielded negative SRI results.

Glover (2010) observed that SRI presents a categorical problem for agronomic science, which for the sake of running field trials and maintaining experimental control, tends to group crop management systems into rigid, and perhaps artificial categories that are not reflected in the wider range of farmers' practices. Clearly, neither recommended management nor SRI practices are static, nor are they diametrically opposed. Farmers are unconcerned with labels, and continuously adapt agricultural technologies to respond to changing agronomic and socioeconomic circumstances. However, NGOs conducting on-farm trials of SRI often introduce it using all six components and compare it to farmers' management practices (FPs) (e.g. Styger et al., 2011a; Thomas and Ramzi, 2011) alone, without clear emphasis on farmer-led adaptation or experimentation, both of which can improve the appropriateness of agronomic management methods, as shown by Bentley et al. (2010) and Van Mele et al. (2011). Such "static" SRI vs. FP comparisons also leave other improved and integrated crop management options unexplored, and assume *a priori* that the full suite of SRI components is the best-bet alternative to FP. Alternative assessments should therefore not only contrast SRI to lower-bound FP controls, but also to an upper-bound control comprised of the best recommended crop management practices (RMPs) for the region, and encourage farmers to adapt each system's components to suit their individual needs. However, while several studies have catalogued farmers' preferences for SRI's components (e.g. Senthilkumar et al., 2008; Sinha and Talati, 2007), or considered farmer adoption and modification pathways (Styger et al., 2011b), we are unaware of experimental efforts to explicitly encourage and/or track farmers' efforts to learn from and modify either SRI or RMP to fit local production opportunities and constraints.

This study uses an alternative, action research approach to farmer-managed field trials. Action research prioritizes reflective discussion and information sharing between farmers and researchers to develop collaborative solutions to practical problems. Based upon a foundation of social empowerment and interactive participation (Pretty, 1995), action research as applied in this study uses experiential learning methodologies to facilitate critical reflection and deliberation, thereby producing actionable knowledge to enable adaptive experimentation (Kolb, 1984). We present three seasons of results from farmer-managed experiments in three irrigation schemes in the middle Senegal River Valley. Our objectives were (i) to assess the agronomic and social viability of SRI and RMP in comparison to FP, (ii) to evaluate the constraints and opportunities for water-savings in SRI in different irrigation schemes, and (iii) to use an experiential learning framework to encourage farmers to tailor management systems to suit their local production circumstances. We conclude with discussion on the ways in which similar action research approaches can be used to facilitate researcher–farmer collaboration, and to overcome the problems associated with top-down extension efforts.

2. Materials and methods

2.1. Site descriptions

On-farm experiments were conducted in the middle SRV, during the 2008 dry and wet seasons and 2009 dry season. Meteorological data were collected at Podor, Senegal, 4 km from the experimental sites (Fig. 1). Experiments were conducted in three locations: Nianga, Giua-4 and Oumar Youness (Fig. 2), selected as a cross-section of the region's irrigation scheme types, including large and centrally managed (Nianga), medium-sized and village-based (Guia-4), and small and privately managed (Oumar Youness) irrigation systems (Table 1).

2.2. Planning and learning exchanges

Prior to the 2008 dry season, Farmer Field School (FFS) facilitators familiar with SRI and RMP organized workshops to present these crop management alternatives to farmers' groups. Because of its inclusion as a "special study subject" in regional FFS, farmers at each site had heard of SRI and expressed an interest in assessing its performance, though none of the volunteering farmers had previously attended a FFS or practiced SRI. Similarly, all farmers were aware of recommended management practices, though none had fully implemented them in their own fields. Rice production in the region is male dominated. Accordingly, all participating farmers were men with at least 7 years experience growing rice. Women and children were involved in transplanting and manual weeding activities.

We used experiential learning methodologies based on Kolb (1984) to guide exchanges between farmers and researchers. This involved a four-phase process (Fig. 3). In the first phase, farmers developed experience with RMP and SRI by managing a researcher-designed experiment. In the second phase, both researchers and farmers reflected upon crop management systems in focus group meetings, and through participatory labor quantification activities (see Dorward et al., 2007). Following the first season, we convened a meeting with farmers from all sites. Yield and labor