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Farmers' views on the future prospects of aerobic rice culture in Pakistan

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ABSTRACT

In parts of Pakistan, the sustainability of conventional flooded rice systems is threatened by diminishing resources, particularly – land, water, and labour. The adoption of aerobic rice system (ARS), an alternative to the conventional systems, could considerably increase resource-use efficiencies. Information on farmer perceptions is vital to identify socio-technological factors of adoption. Our aim was to understand and analyse farmer perceptions about ARS in regards to future adoption. We conducted our study in the Pakistani Punjab with three groups of farmers: (I) informant farmers in rice–wheat system who trialled ARS in a participatory research trial (n = 70), (II) rice farmers in rice–wheat, mixed-cropping and cotton–wheat system with no experience of ARS (n = 97), and (III) non-rice farmers in mixed-cropping and cotton–wheat system (n = 48). Data were collected using a pretested semi-structured questionnaire and analysed by using descriptive statistics and chi-square tests. More than half of respondents in groups II and III had never heard of ARS, though, 76% were open to experimenting. Across three groups, farmers perceived ARS as a means of increasing resource-use efficiency particularly for labour, net profitability, and an option for crop diversification in the mixed-cropping system. Perceived threats were weeds, diseases, poor germination, spikelet sterility, low yields, and frequent irrigation requirement. Deciding factors for repeat ARS plantings by group I were: ease of operation due to direct seeding, good income, and low input requirement. Deciding factors against repeat plantings were: unavailability of suitable fine grain *basmati* varieties, falling water table, weed problem, and unsuitable soil type. The results suggest that aerobic rice is an interesting alternative to traditional rice production as evident from the willingness to plant again by 73% group I demonstration households but the unavailability of well-adapted *basmati* varieties hampers its expansion. Farmers' appreciation of risks and benefits can pave the way for large-scale adoption. Associated risks can be reduced by filling the identified knowledge or technological gaps through additional research and farmer awareness programmes.

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Introduction

The sustainability of conventional flooded rice systems is threatened by diminishing resources of water, labour, and energy. Resource conservation technologies (RCTs) are being developed and propagated to increase rice production worldwide (Consultative Group on International Agricultural Research (CGIAR), 2010; International Rice Research Institute (IRRI), 2010).

Aerobic rice (AR) (i.e. growing rice by dry direct seeding in non-puddled, non-flooded fields under non-saturated (aerobic) soil conditions just like other upland crops such as wheat or maize) is one of the technologies showing great potential to improve resource use efficiencies, in systems constrained by scarcity of the precious resources. Aerobic varieties, developed by crosses between traditional lowland and upland varieties combine some of the yield potential enhancing traits of lowland varieties with adaptation to aerobic soils (Atlin et al., 2006). AR systems (ARS) have been developed in temperate environments and efforts are underway to extend these systems to tropical and subtropical regions to enhance local farm incomes and regional/national food security (Maclean et al., 2002; Prasad and Donald, 2011).

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Paddy rice is traditionally grown by transplanting 25–35 day old seedlings in well prepared, puddled fields (puddling is done by ploughing, harrowing and field levelling under submerged soil conditions to control percolation and weed growth) requiring huge quantities of freshwater. The challenge for Pakistan is to ensure food security while water resources are diminishing and population growth remains high at 2% per annum (Briscoe and Qamar, 2009). During the summer of fiscal year-2011/12 (1st July to 30th June), surface water availability from canal irrigation was 10% less than the long-term average system use of 128 billion m^3 (Government of Pakistan (GOP), 2012). Water tables are falling at a rate of approximately 0.3 m per year (Hussain, 2002) and over the years have declined by more than 7 m due to exploitation of groundwater (Kahlown et al., 2007). Increasing diesel and electricity prices lead to high costs for pumping groundwater, causing decreased net economic profits. Labour shortage during critical growth periods is another important issue. Manual uprooting and transplanting of nursery is an arduous task, especially at the high temperatures of around 35–40 °C. The scarce labour force consists predominantly of unskilled and contractual women and teenagers, resulting in a lack of quality assurance such as uneven plantings and resultantly plant densities much lower than agronomically optimal (Chaudhary et al., 2001; Baloch et al., 2005, 2007; Farooq et al., 2011).

In response to the challenges of water scarcity, labour shortage, huge energy consumptions, and low farm income, RCTs including zero tillage (no-till farming to avoid disturbing the soil), direct seeding, parachute transplanting (rice seedlings grown in plastic trays are uprooted with soil boll and tossed onto puddled fields), bed planting, laser land levelling, and crop residue management were introduced to South Asia by a rice–wheat consortium (RWC) for Indo-Gangetic plains (IGP), which involved international agricultural research centres and national agricultural research organisations (Pakistan Agricultural Research Council – Rice–Wheat Consortium (PARC-RWC), 2003; Jehangir et al., 2007; Kahlown et al., 2007; Pakistan Agricultural Research Council (PARC), 2010). Zero tillage and laser land levelling (both for wheat) were the most widely adopted in Pakistani Punjab (Ahmad et al., 2007). More recently, water-saving technologies for rice viz. alternate wetting-drying, direct seeding, mechanised/partial system of rice intensification, and ARS, have been tested and upscaled in Punjab and Sindh provinces by the Pakistan Agricultural Research Council (PARC) in collaboration with national and international research organisations (IRRI, 2010; Sharif, 2011). For a discussion of the differences between these technologies we refer to Bouman et al. (2007). Here we are interested in the performance of ARS, where instead of transplanting, the crop is direct seeded. Direct seeding reduces the labour requirement for establishment by transferring field activities to periods when labour costs are comparatively lower (Pandey et al., 2002; Pandey and Velasco, 2005). The availability of chemical weed control methods further reduces the labour requirement for weeding later in the season (Farooq et al., 2011). Irrigation is applied to unpuddled fields when soil water drops below critical levels. This generally lowers yields, but also lowers labour and water inputs. The overall result can be a more profitable and environmentally-sustainable rice production system. For these reasons, ARS may be an attractive 'technology package' in water limited environments (Bouman et al., 2005, 2007). We used the term ARS for the whole package of agronomic practices and biophysical and socio-economic boundary conditions and the term AR to refer to technological aspects (e.g. variety) or the crop growing under aerobic conditions. It is the agronomic practices and biophysical and socio-economic boundary conditions, which together determine viability and chances of adoption.

Major activities by PARC regarding ARS included germplasm testing, demonstration plots, and farmers' participatory research trials. Promising results for water and labour savings were reported in the trials (IRRI, 2010; PARC, 2010). The successful conduct of experimental trials or demonstration plots, however, is not a guarantee that the new technology will be adopted. There are different socio-technological factors that determine adoption or disadoption. With 'disadoption' we mean that farmers may try a new technology for one or two cropping seasons and abandon it if it did not deliver what they were hoping for, or if it caused unexpected negative side effects. Farmers may have perceptions about the viability of this technology without any first-hand experience. Hence, we included farmers with and without experience with ARS in our survey. Perceptions determine chances of initial adoption, experiences determine chances of dis-adoption versus repeat plantings.

Assessments of farmers' understandings can help in identifying the socioeconomic and technological factors that inspire or restrain the process of adoption. (Adesina and Baidu-Forson, 1995; Negatu and Parikh, 1999; Erenstein, 2010; Areal and Riesgo, 2014). Access to relevant knowledge and information is a deciding factor for the adoption or disadoption of a resource conservation technology (Jafry et al., 2013). Farm size is another important determinant of adoption due to associated factors such as fixed costs of a new technology, risk preferences and credit availability (Feder et al., 1985). Farm size was identified as a factor influencing the adoption of reduced tillage technologies in Pakistani Punjab (Sheikh et al., 2003). Perceptions and experience also change over time (e.g. studies on the adoption of modern rice varieties by Li et al., 2010) and farmers' interest may diminish with the passage of time (Flor, 2007). Based on interviews conducted intermittently during 2005 and 2007 in Bulacan province of the Philippines, Flor (2007) analysed the perceptions about AR technology and concluded that decision-making criteria for adoption of AR were extension pathways, economic advantage, suitability for existing cropping pattern and other farmer-specific factors. Based on the lessons learned from farmers in Punjab state of India by Mahajan et al. (2013) and across all major rice ecosystems of Sri Lanka by Weerakoon et al. (2011), the authors highlighted the need for development and transfer of location-specific technologies for different agro-ecological regions to enhance resource-use efficiency, net profitability, and sustainable rice production in South Asia.

In our work we have sought to avoid two methodological pitfalls often encountered in technology adoption studies. Often projects introduce technologies and simultaneously investigate farmers' perceptions. This may lead to positive bias in impact assessment studies (Erenstein, 2012). Farmers may participate in trials out of curiosity or sheer peer pressure, factors not considered when technology adoption is monitored simultaneously by the same organisation. We interviewed farmers independently one year after participating in water-saving rice project implemented by PARC. Another typical characteristic of many technology adoption studies is that only farmers to whom the technology was introduced are interviewed (e.g. Flor, 2007). Such a group may not be representative for the total population of farmers (e.g. there is a good chance that these farmers already having an increased interest in the technology). To avoid this kind of positive bias, we interviewed farmers who did and did not use the technology before. We also included farmers from areas where rice is not traditionally grown but where it is possible in terms of environmental conditions and emerging marketing/production trends. Inclusion of this group allowed us to assess the broader potential of ARS in our study area. A critical, unbiased analysis of farmers' views can (1) help to characterise the group of farmers for which a technology is potentially interesting, (2) support promotion of the technology by drawing on experience by early adopters, and (3) provide guidance for further technology development.

To date, there has been very little research on farmer perceptions, adoption and disadoption of ARS in Pakistan (IRRI, 2010;

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