Available online at www.sciencedirect.com
ScienceDirect
Agricultural Systems 93 (2007) 1–24
AGRICULTURAL SYSTEMS
www.elsevier.com/locate/agsy

Environmental impact and economic benefits of site-specific nutrient management (SSNM) in irrigated rice systems

M.F. Pampolino [a], I.J. Manguiat [a,1], S. Ramanathan [b], H.C. Gines [c], P.S. Tan [d], T.T.N. Chi [d], R. Rajendran [e], R.J. Buresh [a,*]

[a] *Crop, Soil and Water Sciences Division, International Rice Research Institute, DAPO Box 7777, Metro Manila, Philippines*
[b] *Tamil Nadu Agricultural University, Coimbatore 641003, Tamil Nadu, India*
[c] *Philippine Rice Research Institute, Maligaya, Science City of Muñoz, 3119 Nueva Ecija, Philippines*
[d] *Cuu Long Delta Rice Research Institute, Omon, Cantho, Viet Nam*
[e] *Tamil Nadu Rice Research Institute, Aduthurai 612101, Tamil Nadu, India*

Received 13 May 2005; received in revised form 24 March 2006; accepted 13 April 2006

Abstract

Site-specific nutrient management (SSNM) provides a field-specific approach for dynamically applying nutrients to rice as and when needed. This approach advocates optimal use of indigenous nutrients originating from soil, plant residues, manures, and irrigation water. Fertilizers are then applied in a timely fashion to overcome the deficit in nutrients between the total demand by rice to achieve a yield target and the supply from indigenous sources. We estimated environmental impact of SSNM and evaluated economic benefits in farmers' fields in southern India, the Philippines, and southern Vietnam for two cropping seasons in 2002–2003. On-farm research comparing SSNM and the farmers' fertilizer practice showed increased yield with SSNM for the three locations, even with reduced fertilizer N rates in some

* Corresponding author. Tel.: +63 2 580 5600; fax: +63 2 580 5699.
E-mail address: r.buresh@cgiar.org (R.J. Buresh).
[1] Present address: Soil Science Division, Agricultural Systems Cluster, College of Agriculture, University of the Philippines Los Baños, College, Laguna 4031, Philippines.

0308-521X/$ - see front matter
doi:10.1016/j.agsy.2006.04.002

cases. SSNM increased partial factor productivity (kg grain kg^{-1} fertilizer N) when fertilizer N use efficiency with the farmers' fertilizer practice was relatively low such as at locations in Vietnam and the Philippines. Use of on-farm data with the DNDC model revealed lower percentage of total N losses from applied fertilizers with SSNM during an annual cycle of cropping and fallows. At the location in India, SSNM showed the potential of obtaining higher yields with increased fertilizer N use while maintaining low N_2O emissions. SSNM in the Philippines and Vietnam showed greater yields with less fertilizer N through improved fertilizer use efficiency, which could reduce N_2O emissions and global warming. Use of SSNM never resulted in increased emissions of N_2O per unit of grain yield, and in environments where higher yield could be obtained with less fertilizer N, the use of SSNM could result in reduced N_2O emissions per unit of grain yield. For the economic analysis, data were generated through focus group discussions (FGD) with farmers practicing SSNM and with other farmers not practicing SSNM. Based on FGD, the seasonal increase in yield of farmers solely due to use of SSNM averaged 0.2 Mg ha^{-1} in southern Vietnam, 0.3 Mg ha^{-1} in the Philippines, and 0.8 Mg ha^{-1} in southern India. Farmers practicing SSNM at the study site in India used less pesticide. The added net annual benefit due to use of SSNM was 34 US$ ha^{-1} $year^{-1}$ in Vietnam, 106 US$ ha^{-1} $year^{-1}$ in the Philippines, and 168 US$ ha^{-1} $year^{-1}$ in India. The increased benefit with SSNM was attributed to increased yield rather than reduced costs of inputs.

Keywords: DNDC model; Focus group discussion; Global warming potential; Nitrogen management; Paddy rice systems; Site-specific nutrient management

1. Introduction

Site-specific nutrient management (SSNM) is a low-tech, plant need-based approach for optimally applying N, P, and K to rice (IRRI, 2006). It enables farmers to dynamically adjust fertilizer use to fill the deficit between the nutrient needs of a high-yielding crop and the nutrient supply from naturally occurring indigenous sources such as soil, crop residues, manures, and irrigation water. The SSNM approach aims to apply nutrients at optimal rates and times to achieve high rice yields and high efficiency of nutrient use by the crop. It does not specifically aim to either reduce or increase fertilizer use (Buresh et al., 2005). It is based on scientific principles developed through nearly a decade of on-farm research throughout Asia.

The initial concept of SSNM was developed in the mid-1990s and then evaluated from 1997 to 2000 in about 200 irrigated rice farms at eight sites in six Asian countries (Dobermann et al., 2002, 2004). The SSNM practices developed and evaluated in farmers' fields before 2001 increased yield and profit as compared to farmers' fertilizer practices (Dawe et al., 2004). Since 2001 the initial SSNM concept had been systematically transformed through collaboration with national agriculture research and extension systems in Asia into a simplified framework for dynamic plant-need based management of N, P, and K for rice. Refined SSNM recommendations have been developed and evaluated through on-farm research involving thousands of farmers in major rice-growing areas of Bangladesh, China, India, Indonesia, Myanmar, the Philippines, Thailand, and Vietnam.