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Effect of leaf color chart on N fertilizer and insecticide use in rice: a case study in West Bengal, India

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During the green revolution in Asia, a common practice was to recommend a standard package of fertilizer rates for the cultivation of modern rice varieties. Later, it became clear that these blanket recommendations were not efficient because the soil's indigenous nutrient supply capacity varies widely among rice fields (Dobermann and White 1999, Olk et al 1999). The current scenario is that farmers apply more N than other nutrients because N fertilizers are relatively cheap and are often sold at subsidized prices (CREMNET 1998a) and farmers can observe impact on plant growth. Overuse and improper timing of fertilizers are common, which is inefficient and sometimes damaging to the crop. Studies show that N recovery by rice is low, ranging from 20% to 40%, because of losses through ammonium volatilization, denitrification, runoff, and leaching (De Datta and Buresh 1989, Win 2003) and that proper timing of N application is critical to minimizing N loss and increasing recovery (Becker at al 1994, Peng et al 1996, Cassman et al 1998). Unbalanced use and excessive use of N fertilizers also lead to overgrowth, making plants succumb to lodging as well as to opportunist pests such as certain diseases and planthoppers. The consequence is increased use of pesticides.

The leaf color intensity of rice is directly related to leaf chlorophyll content and leaf N status (CREMNET 1998b). Therefore, use of a chlorophyll meter (SPAD) in determining the timing of N application can minimize excessive use of N fertilizer without sacrificing yield and can increase N-use efficiency (Peng et al 1996, Balasubramanian et al 1999). But the high cost of acquisition restricts the adoption of the SPAD by most Asian rice farmers with tiny landholdings (Win 2003). However, the development and improvement of a cheap leaf color chart (LCC), which costs less than US$1 per unit, removed this barrier and resulted in wide-scale adoption for real-time N management in rice (Balasubramanian et al 2000).

IRRI made an effort to validate the effectiveness of the LCC with farmer participatory experiments in India under an IFAD-funded special project. The LCC was first introduced in the boro (dry) rice season of 2002-03 to 10 farmers per village, one village per district, in six districts of West Bengal. From the following prekharif (premonsoon) rice season, the LCC introduction was mainly concentrated in selected villages in Nadia District. In total, the LCC was introduced to 163 farmers in 2003-04, 53 in 2004-05, and 43 in 2005-06. In all cases, farmers were allowed to keep the LCC for use in other plots of their farms as well as for sharing with other farmers.

In 2006, a survey was conducted to assess the impact of real-time N fertilizer management with the LCC using a prestructured questionnaire. A random sampling method was used to select samples from villages under the LCC validation experiment (intervention village) and adjoining villages not covered by the project (control village). The survey covered 210 farmers in eight intervention villages and 178 farmers in seven control villages. This note reports the findings of the survey on the impact of real-time N management on the use of N fertilizer and insecticides.

Table 1. Effect of LCC adoption on N use, by season.

Season	N used (kg ha^{-1})		N saved		t value of the difference in means
	Farmers' practice (control plot)	LCC-monitored plot	Kg ha^{-1}	% over farmers' practice	
Prekharif (premonsoon)	115.7	93.2	225	19.5	5.81**
Kharif (monsoon)	121.2	100.4	20.8	17.2	13.63**
Boro (winter/dry)	151.4	119.6	31.8	21.0	4.42**
Av[a]	129.4	104.4	25.0	19.4	

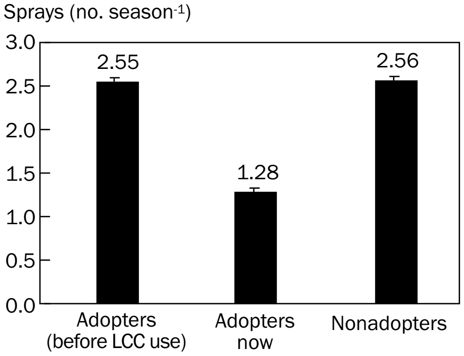
[a] There were 148 LCC adopters and 240 nonadopters in the sample.

Table 2. Effect of LCC adoption on grain yield, by season.

Season	Grain yield (t ha^{-1})		Yield increase (kg ha^{-1})	t value of the difference in means
	Farmers' practice (control plot)	LCC adopted plot		
Pre-kharif (pre-monsoon)	3.35	3.37	20	0.72 ns
Kharif (monsoon)	3.43	3.47	40	1.71 ns
Boro (winter/dry)	4.82	4.91	90	2.73**
Av[a]	3.87	3.92	50	

[a] There were 148 LCC adopters and 240 nonadopters in the sample.

In all three rice seasons, LCC adopter farmers used significantly less N fertilizer than nonadopters (Table 1). Reduced N use by LCC adopters did not affect grain yield in any of the seasons (Table 2). Rather, the adopters produced slightly higher yields than did nonadopters—about 19, 43, and 95 kg ha^{-1} higher in the prekharif, kharif, and boro season, respectively. N fertilizer savings by LCC adopters were on average 25 kg N ha^{-1} (54 kg urea ha^{-1}), a 19% savings over the current practice. The rates of N savings in the different rice seasons were similar—this was highest at 31 kg N ha^{-1} (67 kg urea ha^{-1}) in the boro season, followed by 23 kg N ha^{-1} (50 kg urea ha^{-1}) in the prekharif season, and 20 kg N ha^{-1} (44 kg urea ha^{-1}) during kharif.



Effect of leaf color chart (LCC) adoption on the use of insecticide in rice.

Adopter farmers also reported low insect pest incidence in fields where N fertilizers were used according to LCC readings. Farmers reduced the number of insecticide sprays from an average of 2.55 per season to 1.28 (n=148) (see figure). The LCC adopters reduced insecticide sprays by 50%, which was significantly lower than what they used to apply before LCC adoption (t value for the difference in means = 30.3). The average number of sprays made by nonadopter farmers was similar to that by adopter farmers before the introduction of the LCC (2.56 sprays per season).

The findings show that LCC use contributes to a reduction in the use of N fertilizer and insecticides without any effect on grain yield, thereby increasing farmers' income. Adoption of the LCC for real-time N fertilizer management over a large area will have a positive role in environmental protection.

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Simulating greenhouse gas emissions from Indian rice fields using the InfoCrop model

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Rice production in South Asia has increased markedly with the widespread adoption of modern crop production technologies. In India, the production of rice, the country's most important staple food crop, increased from 53.6 million t in 1980 to about 90 million t in 2005. Crop management practices have also undergone drastic changes in recent decades, with the heavy use of irrigation, fertilizers, and pesticides, making the crop more energy-intensive. These changes have a direct impact on the emission of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from Indian rice fields.

As a signatory to the United Nations Framework Convention on Climate Change, India has agreed to assess GHG emissions from all development sectors, including agriculture. This quantification of GHG emissions from agriculture is needed in the context of ecosystem modification and climate change. There are, however, uncertainties in the estimation of GHG emissions from Indian agriculture because of diverse soil and climatic conditions and limited on-farm measurements. Simulation models can be helpful in minimizing these uncertainties and determining the impact of input use on global warming. Simulation modeling also provides a baseline from which future emission trajectories may be developed to identify and evaluate GHG mitigation strategies. The objective of our study was to simulate GHG emissions from rice fields under different management practices in different regions of India.

The InfoCrop model, a generic dynamic crop model used in the study, simulates soil nitrogen and organic carbon dynamics and GHG emissions. It has been validated in a variety of agro environments in India (Aggarwal et al 2006). Upscaling of GHG emissions from rice fields in India was done using the validated model and geographic information system. The required input parameters of the model consisted of daily meteorological data (maximum and minimum temperatures, precipitation, and solar radiation); soil characteristics (sand, pH, and thickness of different soil layers); agronomic management practices (date and method of sowing, N fertilizer, and irrigation); and area under different rice ecosystems (irrigated lowland, rainfed lowland, rainfed upland, and deepwater). These were compiled in a database. Simulations were carried out for the 94 agroecological zones (as drawn by India's Plan-