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ANTICIPATED IMPACT ON FERTILIZER DEMAND

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The Expansion of Rice-Maize Systems in Asia: Anticipated Impact on Fertilizer Demand

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Introduction

The demand for maize in Asia is expected to grow in the next 20 years mainly driven by the growth of the livestock and poultry feed industry as regional income increase and Asian consumers shift towards animal-based diets. The rapid expansion of the biofuel industry in recent years and high fossil energy costs also influence global maize demand and supply, pushing maize prices to a historic high.

The increasing demand for maize is rapidly transforming cropping systems in certain parts of Asia. Where the biophysical and socioeconomic conditions are favorable, significant shifts from rice monoculture to more profitable rice-maize systems have either occurred or are emerging (IRRI and CIMMYT 2006). In other areas, future potential for rice-maize systems exist but recent increases in maize demand have primarily been met by imports because knowledge and technologies for rice-maize systems are lacking. Cropping systems-based approaches to crop, nutrient, and other management practices are needed to ensure a sustainable, ecologically-sound diversification and intensification of rice-based systems for increased productivity and profitability to benefit farmers.

A new research alliance

The ecological intensification of agricultural systems is aimed at satisfying the anticipated increase in demand for agricultural products while meeting acceptable standards of environmental quality (Cassman 1999). Traditional, commodity-based research falls short of addressing cropping system-specific management and sustainability issues (IRRI and CIMMYT 2006). Recognizing this challenge, a strategic research alliance between the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT) was formed in 2005 to provide a new platform for research with a particular focus on rice-maize systems, including the mandate for a joint project on Intensive Production Systems in Asia (IPSA). Research activities of the alliance will focus on strategic assessment of rice-maize systems in Asia, developing and disseminating system-tailored germplasm, and resource management solutions for optimizing productivity, profitability and sustainability of rice-maize systems. IPSA has established partnerships in Southeast Asia with national research and extension systems and with ongoing regional commodity-based initiatives for research and technology dissemination, including the Irrigated Rice Research Consortium (IRRC) coordinated by IRRI and a regional project on site-specific nutrient management (SSNM) for maize coordinated by the Southeast Asia Program of the International Plant Nutrition Institute (IPNI) and the International Potash Institute (IPI).

In this paper, we present a case study from Bangladesh where harvested area with maize is expanding rapidly and projected to further increase by 46% until 2010 from the current 137,000 ha (Waddington et al 2006). We present an example from Dinajpur district in Northwest Bangladesh where maize is increasingly replacing wheat after the monsoon (*T. aman*) rice (rice-wheat system, R-W) or *Boro* rice in the cool winter season with irrigation (rice-rice systems, R-R), and discuss its impact on the production potential of the cropping system and on fertilizer demand. The production potential is the sum of the potential yield of all crops grown in a calendar year. Potential yield (Yp) is defined as the theoretical maximum yield that can be achieved as determined by climate and germplasm in the absence of any constraints such as water, nutrients, pests, and diseases. Potential yield is commonly estimated using plant growth models and should not be mistaken for attainable yield, which is the yield that farmers can achieve with optimal water, pest, and general crop management practices. The current actual yield in farmers' fields is often lower due to yield limiting constraints like water, pests and diseases, and poor crop and nutrient management practices.

Methodology

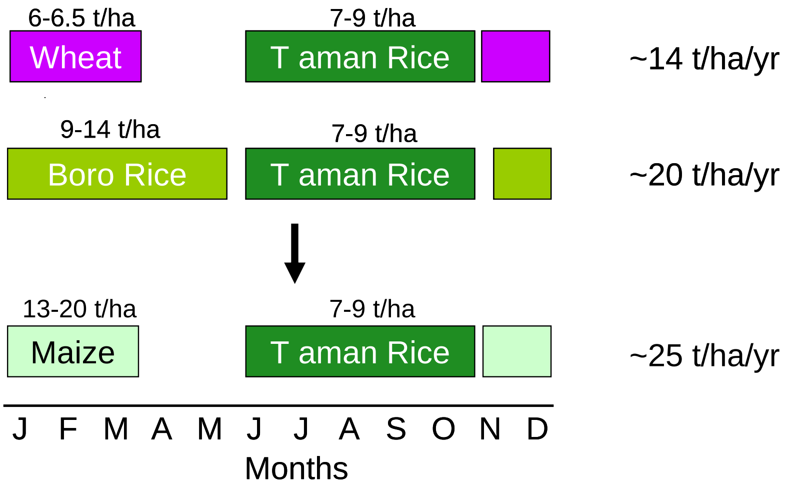
ORYZA2000 (Bouman et al 2001), Hybrid-Maize (Yang et al 2004), and the DSSAT-CERES-Wheat (Hoogenboom et al 2004) models were used to simulate growth and yield of rice, maize, and wheat, respectively, for Dinajpur district Bangladesh. The yield potential of rice, maize, and wheat were estimated using 20 years of historical weather data from the National Aeronautics and Space Administration (NASA) across 12 planting dates (1st of each month) for rice and maize and four planting dates (Nov 1, Nov 15, Dec 1, and Jan 1) for wheat. Rice varieties of four growth durations ranging from extra early (80-90 days) to late (125-140 days) were chosen. For maize, four hybrid maturities of 1500, 1600, 1700, and 1800 growing degree days (GDD) were selected. Kanchan variety of wheat was used under optimal planting conditions. Based on simulated Yp of rice, maize, and wheat following the current cropping calendar, we estimate the production potential of three cropping systems (rice-rice, R-R; rice-wheat, R-W; rice-maize, R-M). Fertilizer use is estimated from the current farmers' fertilizer rates.

Results

The potential yield of the main rice crop (T. aman rice) planted during the rainy season in June/July is about 7-9 t/ha. When grown towards the cooler months of the year, Yp increases but with associated risks of cold injury during flowering or during the seedling stage. The yield potential of maize is highest when planted during the period September to November (up to 20 t/ha), while wheat is ideally planted in November achieving a yield potential of about 6.5 t/ha.

Figure 1 given below shows the production potential of rice-wheat, rice-rice, and rice-maize systems. There is no alternative to growing rice in the rainy season (T aman rice) so that the production potential changes depending on the second crop grown after rice. The production potential is highest in rice-maize systems with about 25 t grain per ha and year, followed by in rice-rice (20 t/ha/yr) and rice-wheat systems (14 t/ha/yr).

Figure 1. Potential grain production of rice-based cropping systemsin Dinajpur, Bangladesh.



Current farmers' fertilizer rates for T. aman rice, boro rice, wheat, and winter maize are shown in Table 1. These rates are likely not chosen to meet actual nutrient requirements for high productivity and profitability. In some cases, fertilizer rates may be too low, in others too high. We suspect that particularly N rates in winter maize are applied in excess of plant N requirements. Site-specific nutrient management approaches developed for rice (IRRI 2007) and maize (Witt and Pasuquin 2007; Witt et al 2006) present opportunities to further optimize nutrient management as farmers replace crops in their crop rotations.

Table 1. Current farmer fertilizer rates (kg/ha) for different crops in Dinajpur, Bangladesh.

Fertilizer	Unit	T. aman rice	Boro rice	Wheat	Winter maize
N	kg/ha	105	117	105	233
P_2O_5	kg/ha	28	58	46	80
K_2O	kg/ha	9	45	30	81

Source: Y. Ali, BARI (unpublished data).

Because crop yield is directly related to the amount of nutrients taken up by a crop, fertilizer consumption is expected to increase when farmers shift from either a R-R or a R-W system to a R-M system (Table 2) due to a greater demand for nutrients at higher production levels.

Shifting from one crop to another is likely to have moderate impact on fertilizer demand, while shifting from a single to a double or from a double to a triple-cropping system would result in increased fertilizer consumption and demand, as well as increased farmers' productivity.

Table 2. Fertilizer NPK use in rice-rice, rice-wheat, and rice-maize systems in Dinajpur, Bangladesh estimated from current farmer fertilizer rates by crop (kg/ha) provided in Table 1.

Cropping system	N (kg/ha)	P_2O_5	K_2O
Rice-rice	222	86	54
Rice-wheat	210	74	39
Rice-maize	338	108	90

Conclusions

The increasing area with rice-maize rotation in Asia has prompted international research organizations and national agricultural centers into a partnership to address agricultural research issues at the cropping system level. Concepts, tools, and technologies such as site-specific nutrient management that have been successfully developed and evaluated for single crops are now used to respond to the rapid change in cropping systems in some Asian countries by designing and evaluating alternative cropping systems following the principles of ecological intensification.

A case study from Bangladesh using current farmer fertilizer rates indicates that changing from either a rice-rice or a rice-wheat system into a rice-maize system will have a moderate impact on fertilizer demand. Significantly greater fertilizer consumption is expected where a new crop is introduced into an existing cropping system. Further work is needed to fully assess the impact of expanding rice-maize systems on fertilizer demand with optimal nutrient use.

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