Towards a Site-Specific Nutrient Management Approach for Maize in Asia

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A new regional initiative has the goal of improving the productivity and profitability of maize in key agro-ecological zones of Southeast Asia through site-specific, integrated nutrient and crop management.

Maize is the second most important cereal crop in Asia, not only as a staple food, but also as a major component of feeds for the animal industry. The total area planted to maize in Southeast Asia is currently about 8.6 million hectares (M ha), with the largest areas in Indonesia (41%), the Philippines (29%), Thailand (13%), and Vietnam (12%). The growing demand in the region cannot be met despite the increase in domestic production and yield of maize in the last 15 years (**Figure 1**).

Indonesia's maize production and yield, for example, continue to increase. Yet the country imported more than 1 million metric tons (M t) of maize annually in the last 5 years. Average national yield in Indonesia, Thailand, and Vietnam is only 3 to 4 t/ha (2 t/ha in the Philippines) and knowledge on yield potential, exploitable yield gaps, and constraints to improving productivity at the field level is still limited.

We have therefore launched a new, 3-year project in collaboration with key research institutes in Indonesia, the Philippines, and Vietnam. Objectives

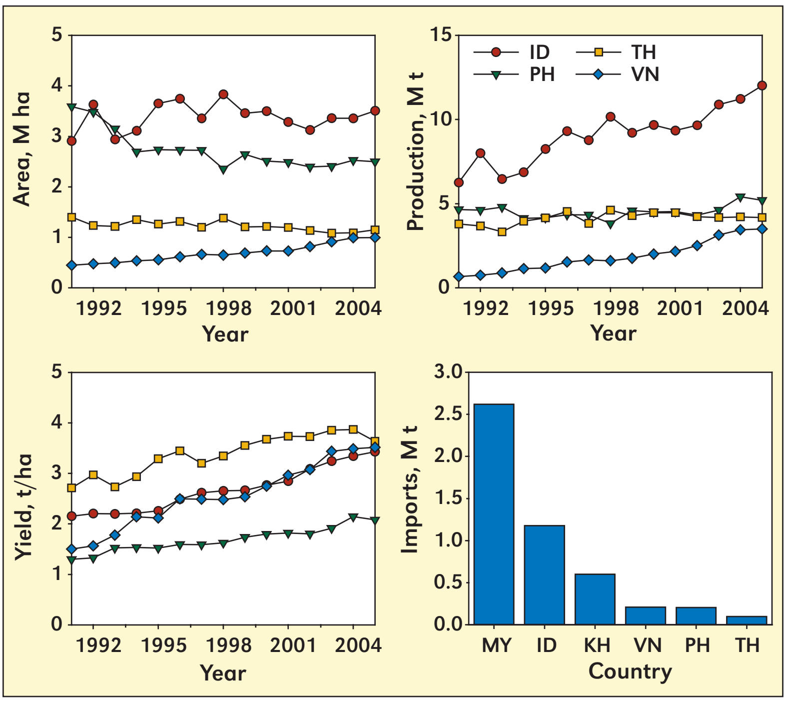
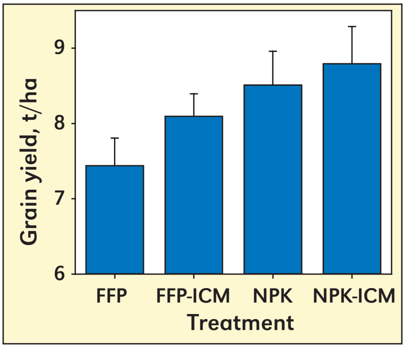


Figure 1. Area, production, and yield of maize in selected countries in Southeast Asia 1991-2005. Maize import data are the average of 2000-2004. Data source: FAOSTAT 2006 (www.fao.org). ID = Indonesia; KH = Cambodia; MY = Malaysia; PH = Philippines; TH = Thailand; VN = Vietnam.

Figure 2. Grain yield of hybrid maize in 30 farmers' fields at five key maize sites in Indonesia, 2004-2005. FFP = Farmers' Fertilizer Practice; NPK = treatment with ample application of fertilizer N, P and K; ICM = Improved Crop Management.



include: i) quantify and understand the yield potential of maize and ii) develop, evaluate, and disseminate site-specific nutrient management (SSNM) and best crop management practices for maize. The project currently supports a network of 120 on-farm experiments in these three countries. Treatments always include omission plots (-nitrogen [N], -phosphorus [P], and -potassium [K]) to estimate nutrient-limited yield, a fully-fertilized treatment with ample N, P, and K fertilizer to estimate attainable yield, and a farmers' fertilizer practice (FFP) plot to serve as a benchmark for comparison. In general and except for FFP, fertilizer N is applied in three relatively equal splits at crop establishment, and growth stages V5 to 6 and V7 to 8, all fertilizer P and K is applied together with the basal N dose, in some cases 50% of fertilizer K was applied with the last N application. Improved crop management (ICM) plots were established at all sites, but treatments varied from site to site depending on opportunities for improvement. ICM treatments included changes in planting density or application of manure or lime. Varieties grown always included a farmer-selected hybrid and, in some cases, open-pollinated varieties (OPV). Following are preliminary results of the first season experiments.

Fertilizer application in South Sulawesi, Indonesia.

Indonesia

Thirty on-farm trials were conducted in five key maize-producing provinces that account for 80% of Indonesia's maize production. Sites represent a wide range of climate, soils, cropping systems, and cropping practices. Hybrid maize was grown in all trials and ICM treatments varied depending on site. Across all sites, a highest average yield of 8.8 t/ha was achieved in NPK-ICM treatments, which was 19% or 1.4 t/ha higher than the yield achieved by farmers (**Figure 2**). The yield increase was related to both improved crop and nutrient management. Average yield at sites ranged from 7.2 t/ha in Central Java to 10.9 t/ha in East Java (**Table 1**). Highest yield in individual fields recorded at each site ranged from 9.4 t/ha in Lampung to 13.7 t/ha in Central Java, which was close to the genetically and climate determined yield potential simulated with the model Hybrid-Maize >**http://www.hybridmaize.unl.edu**<.

Table 1. Maize yield and yield response to fertilizer N, P, and K application in five farmers' fields at each experimental site, Indonesia, one season, 2004/05. Data are the average across treatments with and without improved crop management.

Site	Yield response, t/ha +N	Yield response, t/ha +P	Yield response, t/ha +K	Yield, t/ha +NPK	Highest yield, t/ha +NPK	Potential yield[1], t/ha
North Sumatra	2.5	1.5	0.8	10.8	11.6	-
Lampung	2.4	0.6	1.1	7.6	9.4	10.1
Central Java	4.7	1.6	0.7	7.2	13.7	12.0
East Java	4.0	0.5	0.8	10.9	12.8	13.9
South Sulawesi	1.9	1.7	1.1	7.8	9.6	-
All sites	3.1	1.2	0.9	8.7	11.4	12.0

[1] Based on Hybrid-Maize model simulation

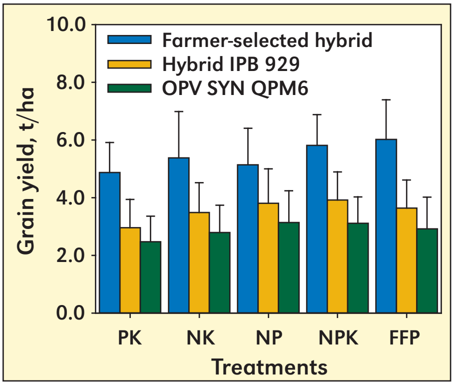


Figure 3. Grain yield of selected maize varieties in three farmers' fields, Isabela, Philippines, 2005. Data are the average across planting density.

The Philippines

One of the three project sites in the Philippines is located in the province of Isabela, which has 200,000 ha of land under maize and contributes 25% of the total production in the country. Five on-farm trials were conducted at this site during the 2005 wet season (May to October). Three varieties (farmer-selected hybrid, hybrid IPB 929, and OPV SYN QPM6) were planted at two densities of 83,000 plants/ha as commonly practiced by farmers and 67,000 plants/ha as suggested by researchers. Only data from three sites could be harvested because of severe drought in two farms. Yields were close to 6 t/ha in NPK treatments and the highest yield recorded in a single farm was 8.2 t/ha.

There was no significant difference in yield among NPK and FFP treatments. The average plant population at harvest was 27 to 29% lower than at seeding because of severe rainfall during emergence and drought problems during the growing season. Real-time nutrient management strategies are needed at sites with such variation in environmental conditions to adjust fertilizer rates to season-specific conditions. The yield response to fertilizer N, P, or K application was generally small, particularly for N because yield was largely limited by environmental constraints. Larger yield responses to fertilizer application can be expected in years with more favorable weather conditions. There were, however, large differences in yield among varieties (**Figure 3**).

Farmer applying water and fertilizer to maize in the Red River Delta, North Vietnam.

Vietnam

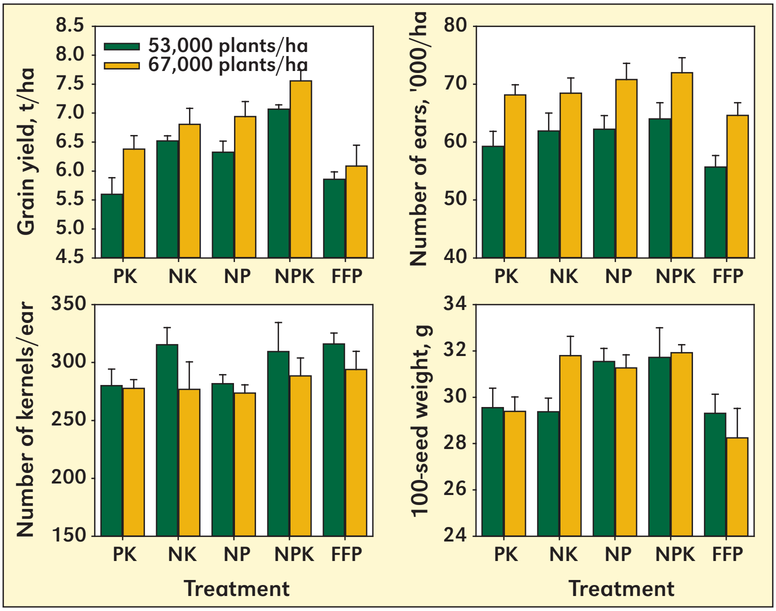
Project sites in Vietnam are located in four major agro-ecological zones representing key areas of corn production (Red River Delta, Central Highlands, Southeastern Vietnam, and the Mekong Delta). The selected provinces account for 65% of Vietnam's total maize production. In 2005, the first 25 on-farm trials were established in three provinces in North, Central, and Southeastern Vietnam. Hybrid varieties were grown at two planting densities that followed farmers' practice and a researchers' recommendation. Average yield in the first season ranged from 6.5 to 7.9 t/ha (**Table 2**).

Nutrient limitations followed the order N>P>K with moderate, average yield responses of 0.9, 0.7, and 0.6 t/ha to fertilizer N, P, and K application, respectively. Fertilizer rates applied by farmers averaged 107 kg N, 30 kg P_2O_5, and 63 kg K_2O/ha. Fertilizer

Table 2. Maize yield and yield response to fertilizer N, P, and K application in five farmers' fields at each experimental site, Vietnam, one season, 2005. Data are the average across two planting density treatments.

	Yield response, t/ha			Yield, t/ha	Highest yield, t/ha
Site	+N	+P	+K	+NPK	+NPK
Sonla	1.1	1.1	0.9	6.6	7.4
Daklak (*Rhodic Ferrasol*)	0.6	0.4	0.3	6.5	8.3
Daklak (*Lithic Luvisol*)	0.9	0.6	0.4	7.9	8.5
Dong Nai (*Luvisol*)	1.3	0.7	0.7	7.3	8.1
Dong Nai (*Ferrasol*)	0.6	0.6	0.5	7.5	8.6
All sites	0.9	0.7	0.6	7.2	8.2

Figure 4. Yield and components of yield in five farmers' fields in Dong Nai Province (Luvisol), Southeastern Vietnam, 2005.



rates in NPK treatments were 180-200 kg N, 90-120 kg P_2O_5, and 120-150 kg K_2O/ha following typical rates applied in fertilizer experiments with maize in Vietnam to exclude nutrient limitations and estimate nutrient-limited yield gaps. The latter will be used to calculate site-specific fertilizer recommendations based on data from two crops.There was a clear trend of increased yield at higher planting densities in all treatments as shown in the example of Long Khanh District in Dong Nai Province (**Figure 4**).

Preliminary results of on-farm trials with maize in Indonesia, the Philippines, and Vietnam clearly indicate sufficiently large yield gaps and significant opportunities to increase yield and profitability, if crop and nutrient management are fine-tuned to site-specific conditions. Farmers will probably need to adjust both timing and amount of fertilizer N, P, and K, and use split applications to better match crop demand for nutrients. Nutrient limitations often became more obvious once other constraints to yield were removed. Plant populations of 65,000 to 75,000 plants/ha are required to achieve high yields under favorable conditions in tropical Asia. In drought-prone areas, plant populations must be lower than that. BC

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