# GMP MID TERM REPORT

## Executive Summary

Ecological intensification (EI) is a termed that has been used to describe a maize production system that "…satisfies the anticipated increase in food demand while meeting acceptable standards for environmental quality." Such a theoretical definition requires research to identify the specific practices that are needed to reach that goal. The Global Maize project challenged scientists around the world to use the best science available to create new management systems that would outperform current farmer practice (FP). Improved crop nutrition was the focus, but many other management factors were included in an attempt to make the best use of the nutrients applied. To aid researchers in evaluating whether or not EI management was yielding close to its true potential, we used the Hybrid Maize crop growth simulation model. To evaluate the N rates that researchers are choosing, we are also planning to incorporate the Maize-N model; however the project has not yet generated enough data to do so. Currently, 20 research centers exist in 9 countries. The project was planned to run for 10 years at each center in order to provide enough time for management practices to affect noticeable changes in the overall cropping system. This report summarizes 41 site-years of data collected from 17 of those centers. The centers not reporting data were recently established.

This Global Maize Project (GMP) has 4 goals: 1) to develop a global network of scientists who are actively working to improve nutrient management of maize using the best science; 2) to use EI practices to improve yields over time at a faster rate than FP while minimizing adverse environmental effects; 3) to test the ability of the Hybrid Maize simulation model to predict yield potential at individual maize locations, and 4) to provide data needed to calibrate a nitrogen nutrition model, Maize-N. We focused on the first three objectives in this report.

### Objective 1: Creating a Network of Scientists Actively Researching Improved Nutrient Management Practices for Maize

Cooperators in the GMP were surveyed and asked to provide feedback on benefits they were seeing by being part of the GMP. Three key findings were:

- Concepts of EI are serving as examples for researchers working with other crops, like rice, sunflower, cotton, sugarcane and wheat. For example, scientists at Darwad and Ranchi, India, initiated work on different agro-climatic conditions following the concepts used in the GMP at those locations.
- GMP is creating a database of information that leads to improvements in fertilizer recommendations. Three examples are: (1) revision of state recommendations in Darwad, India, (2) an increase from 2 to 3 in-season N applications because of the positive impacts seen in Darwad and Ranchi, India, and 3) in Africa, the Kenya Agricultural Research Institute is revising recommendations for maize.

- The project is serving to train students, crop consultants and farmers around the world. Field experiments in some regions are serving as teaching tools. Field days take place in most GMP experiment sites to transfer what is being learned to those who need the information to improve their farming practices. Students, both graduate and undergraduate, are involved in the project in many regions. Scientific work related to GMP will provide data for Master of Science theses and Ph.D. dissertations in different locations.

**Objective 2: Using EI to Improve Yields while Minimizing Adverse Environmental Effects**

Ecological intensification management systems around the world yielded, on average, 8021 kg of grain dry matter (DM) $ha^{-1}$ and increased maize yield above FP by an average of 980 kg grain DM $ha^{-1}$. In 39% of the cases, these increases were statistically significant. In only 2% of the cases did EI significantly decrease yield.

There is currently no commonly accepted set of metrics for evaluating “acceptable standards for environmental quality” when configuring EI systems; however, higher nutrient use efficiency is often cited as a goal for increased sustainability of agricultural systems. We examined four different metrics of efficiency to see what information they provided about the nutrient management approaches used in the project.

We first examined the partial factor productivity (PFP) of nitrogen (N). Forty of the 41 site-years currently provided the necessary data. Partial factor productivity answers the question, “How productive is a maize cropping system in comparison to its nutrient input?” In 58% of the cases, EI management systems either maintained PFP or increased it; however, the overall average PFP of EI was lower than FP due primarily to large decreases at one research center. These decreases turned out to be an anomaly of the PFP calculation. The EI system at this research center used a modest increase in N rate; however, when it was compared to the very low N rate use in FP, the relative increase appeared large. In terms of absolute magnitude, the EI system at this site used N rates that were among the lowest in the entire GMP.

Agronomic efficiency (AE) of N answers the question, “How much is grain yield increased per unit of N applied?” This efficiency is also an indicator of the profitability of N. Data were analyzed from 33 of the 41 site-years. In 9% of the cases, EI systems had significantly higher AE than FP; however, all of these cases occurred at one site where FP was using too much N. The EI system at that location reduced N rates but maintained or increased grain yield. It is worth noting that this site was the only one where significant increases in AE were observed and it is also the only site where EI used lower N rates than FP. When looking at all data from the project, EI systems typically used the same or higher rates of N but were able to maintain AE 85% of the time. In only 6% of the cases did the higher rates used in EI systems reduce AE. Profitable use of N occurred 94% of the time in EI systems and 88% of the time with FP.

Recovery efficiency (RE) of N answers the question, “How much is plant N uptake increased when N is applied?” It is an important component of many N recommendations. Higher RE values result in lower recommended N rates. Data from 19 of the 41 site-years were analyzed. In only one site-year did EI significantly increase RE. In this case, EI maintained yield by reducing N rate 17%. In the majority of the cases (84%), EI systems had the same RE as FP even though they tended to use higher rates of N. In 11% of the cases, EI significantly decreased FP, resulting from either yield decreases or disproportionately large increases in N rate in the EI systems. Averaged across all site-years, RE of both EI and FP systems were very close to global averages reported by others.

Partial nutrient balance (PNB) answers the question, “How much nutrient is being taken out of the system in relation to how much is applied?” It has implications for sustainability, particularly for phosphorus (P) and potassium (K). Taking out more nutrients than are applied reduces soil fertility while doing the opposite builds fertility. Data from 29 site-years for P and 24 site-years for K were examined for changes in PNB between EI and FP. In all cases, EI management used P and K rates that were high enough to build soil fertility. In 21% of the cases for P and 17% of the cases for K, this represented a statistically significant shift away from EI practices that were reducing P and K fertility.

**Objective 3: Evaluating the Ability of the Hybrid Maize Model to Predict Yield Potential**

Sufficient management practice and weather data existed in 32 site-years to simulate either maize grain and/or stover yields for EI using the Hybrid Maize model. For FP, 34 site-years of data existed. Observed yields were compared to simulated yields. When yields were within 80 to 110% of the yield potential predicted by Hybrid Maize, both model performance and management practices were considered acceptable. For grain yield, acceptable performances occurred 44% of the time in EI systems and 29% of the time in FP systems. For stover (leaves, stem, husk, cob, tassel) yield, acceptable performances occurred 28% of the time in both EI and FP systems. In cases where yields and simulations fell outside of this range, we are investigating the causes. Possible causes being examined are: management may have been sub-optimal; growing season conditions may have existed that Hybrid Maize could not account for in its algorithms; and key growth stages may have been inaccurately estimated by the researchers. We may identify other causes as work continues.