Poverty Alleviation through Balanced Fertilization for Corn and Integral Family Development

By José Espinosa, Arturo Melville, and Kenneth Hylton

A high percentage of the rural population of Guatemala lives in poverty. This poverty can be observed in most households and steps to free rural families from this burden can lead to prosperity and stability. With such a high level of poverty, getting money in the pockets of rural poor is particularly important. Agriculture in the highlands of Guatemala centers primarily on corn (maize) production, and is a fundamental part of the region's history and culture. To address the issues of hunger, malnutrition, and future economic autonomy, a robust, sustainable agricultural program is needed. Fertilizer, used in accordance with site-specific nutrient management concepts, is an integral part of that program.

Soft corn varieties for human consumption are grown in extensive areas of the highlands of Guatemala. Farmers own small farms and face limitations in capital and technology, so grain production is generally low. However, sustainable yields have the potential to be high enough to provide adequate income to support the household and provide savings to invest in farm improvement.

According to HELPS International, a non-governmental organization (NGO), a farm family in rural Guatemala needs approximately 1,700 kg of corn per year, but the traditional method of growing corn yields only about 700 kg of corn per year. The head of the family has to work outside his community to obtain the resources needed to purchase additional corn. Increasing the ability of farmers to grow higher yields is one way of helping families to achieve a better way of life.

In 2006, HELPS International developed and implemented an expandable Corn Program for economic and rural development in the province of Alta Verapaz. This effort was started in coordination with DISAGRO, a local fertilizer distributor. In late 2008, The Mosaic Company and International Plant Nutrition Institute (IPNI) joined in the program. Since joining the program, Mosaic has contributed agronomic expertise, soil and plant testing, and greatly expanded the program in the Alta Verapaz region of the country. Today, Mosaic contributes approximately USD 400,000 annually to administer the program and to provide 0% interest loans to the growers. Repayment of these loans by the growers is a condition for them to remain in program. Repayment rates are typically greater than 90%.

Corn farmers in Guatemala are eager to learn about better management.

Corn Program activities started with community organizing. Farmer communities willing to participate in the program were identified and their leaders contacted. A local agricultural association was established at each of the communities with the respective board of directors to handle the Corn Program specifically. The general objective of the Corn Program was to increase grain yield through technical assistance and credit for fertilizer and other agricultural inputs.

Planting four or five seeds in a hill causes uneven growth and is a factor in low yields.

The first region where the program was implemented was Cotzal in Quiché, and began with 24 families and 3.24 ha of land. HELPS has been working in the communities of this region for many years with other poverty alleviation programs. Participating farmers own or rent small plots of land with an average size of 0.5 ha. The specific objective of the Corn Program was to develop farmer skills to produce enough corn to cover the needs of the family for one year with enough surplus to pay back credit and to generate savings. The extra income can cover other basic needs of the family, especially health care and education.

The main limitations of small corn producers in the highlands of Guatemala are soil degradation (erosion), declining soil fertility, and inadequate crop management. Work conducted in the past with small farmers in the highlands of South America has demonstrated that plant population and nutrient

Omission plots help to demonstrate the effects when corn does not receive various nutrients.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Mg = magnesium; B = boron; Zn = zinc.

management can improve and sustain yields high enough to satisfy food need and to help grow income.

Long-term use of the land for corn cultivation, without returning depleted nutrients, degrades soil fertility and lowers yields. The farmers' lack of income prevents use of fertilizers and the cycle of degradation deepens.

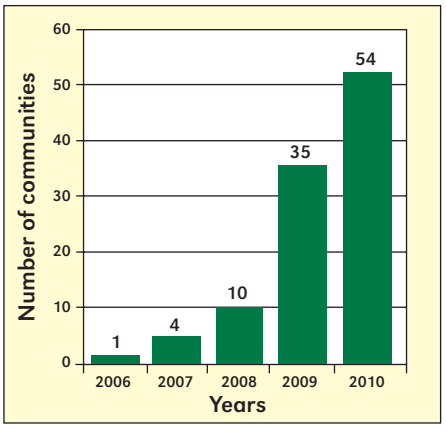

Figure 1. Number of communities included in the Corn Program by year.

It was obvious to HELPS that fertilizer use was a key component of the program. However, crop management by farmers was also not conductive to high yields. Traditionally, small farmers tend to have a very low plant population and uneven distributions of plants in the field. Four to five seeds of local open pollinated corn varieties are placed in a hill and each hill is approximately one meter apart. Plants grow unevenly in the hill due to competition. Farmers tend to plant this way to assure the survival of one or two plants per hill, thus guaranteeing at least some harvest in the prevalent conditions. Attempts to introduce hybrid maize seed was not well received by farmers because the grain was not good for tortillas and other culinary uses in comparison with the locally grown varieties. Given these conditions, the first steps of the program were to help farmers choose good local seed and develop a fertilizer program based on local experience. The initial year was also the time of practical training for the HELPS staff, mostly young bilingual personnel from the area who had agricultural education from vocational schools. The group was led by an agronomist with DISAGRO.

Carrying fertilizer to the field.

The program established a basic balanced nutrition approach to manage fertilizer application. The fertilizer application rate was based on DISAGRO experience and the consensus obtained from other experts in the region. Fertilizer was applied in two split applications, one at planting time and again 45 days later. Planting was conducted using the traditional methods of the farmers. Results of the first year harvest were encouraging, producing grain yields that ranged from 3 to 5 metric tons per hectare (t/ha) in the fertilized farmer fields. Yields of this nature were sufficient to meet the grain needs and to generate surplus to pay the loans. The program showed success and more farmers joined during the following years to reach a total of 54 communities, 1,169 farmers, and a total of 636 hectares in 2010.The growth of the program is presented in **Figure 1** and **Figure 2**.

Based on the experience accumulated by the program in the past, a new more systematic approach was implemented to understand the cropping system and to accumulate reliable

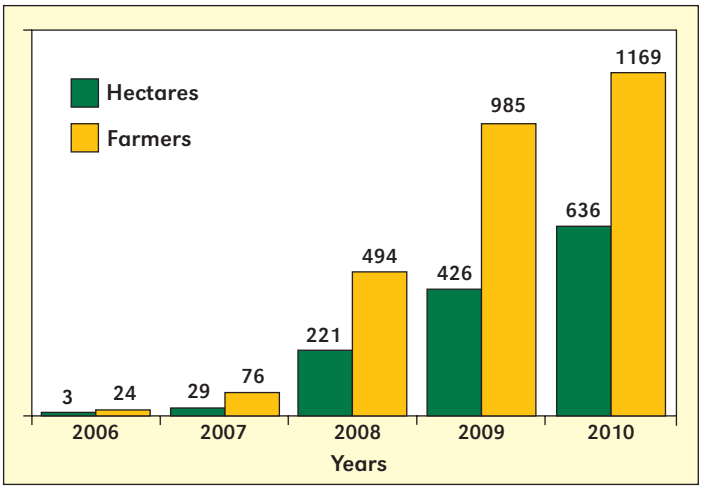

Figure 2. Number of hectares and farmers in the Corn Program.

data to manage the crop. In tropical conditions, corn yield potential and nutrient needs differ among agro-ecological growing zones. The Alta Verapaz region of Guatemala is somewhat different from other areas of the country where there is more information about corn production. These different social and agronomic growing conditions require different nutrient recommendations and crop management approaches. Because soil

Farmer training includes learning about nutrient deficiency symptoms.

testing is rarely used by small farmers, a site-specific nutrient management approach, based on the omission plot technique, was introduced to study the influence of local agro-ecological conditions on nutrient requirements as a tool to develop fertilizer recommendations to achieve high sustainable yields for the region.

For the study, a simple experiment was designed to compare a balanced fertilizer treatment against plots with individual omission of N and P. All experimental plots were planted with a population of 62,000 plants/ha arranged in rows 0.8 m apart and hills 0.4 m apart. Every hill received two seeds. This is a major change in crop management introduced in the experiment to ensure a uniform population. Farmers normally plant 40,000 seeds/ha, locating four to five seeds in each hill, which are unevenly distributed in the field. Competition within the hills leads to only one or two plants producing a good corn ear reducing yield potential. A balanced fertilizer treatment was designed based on the experience accumulated by the program during the past 2 years. The new exploratory balanced treatment was 146-90-74 kg N-P_2O_5-K_2O/ha + 26 kg MgO, 43 kg S, 1.1 kg Zn, and 2.4 kg B/ha. Nitrogen and P omission treatments were also established.

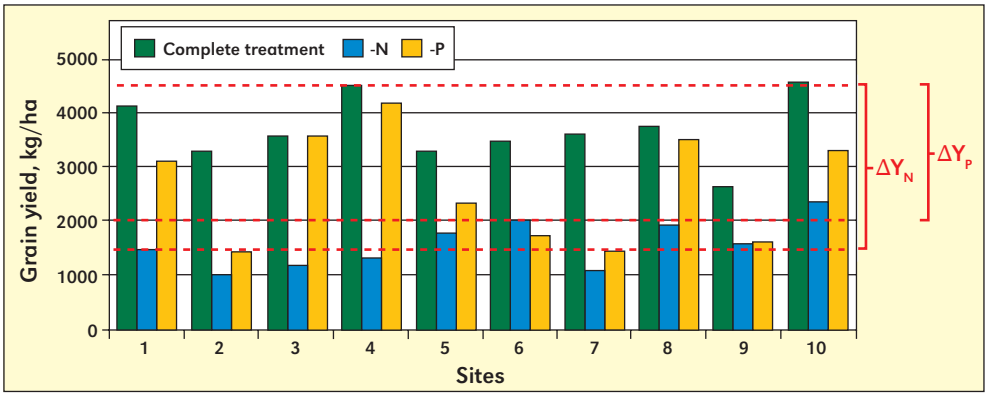

Figure 3. Data from 10 field experiments at Alta Verapaz, Guatemala, comparing a complete balanced fertilizer treatment to N and P omission plots (all nutrients except the nutrient in question). Assumed obtainable yield of 4500 kg/ha.

Ten experimental sites were established at Alta Verapaz during 2009 and 2010. These are plots fertilized with all nutrients except the omitted nutrient, and they allow the determination of the yield that can be obtained with the native soil reserve. Nitrogen in the complete treatment and in the P omission plot was split three times during the cycle: 30% was applied at planting time and 35% at V6 and V10. Field results determined with certainty the attainable yield under this new crop and nutrition management and yields under N and P limitation. This provided enough information to calculate rates needed to achieve a yield target in the coming years. Results from both years are presented in **Figure 3**.

Market time for harvested corn.

Grain yield from the 10 sites ranged from 2.7 to 4.6 t/ha for the complete treatment, with an average of 3.7 t/ha. The N omission plots ranged from 2 to 3 t/ha, averaging 1.6 t/ha, and the P omission plots from 1.5 to 4.2, averaging 2.7 t/ha. The high variation among sites is understandable given the hilly conditions of farmer fields and the natural adjustment to handling the new planting procedure. Some reasonable assumptions can be made from the accumulated data. It can be assumed that a yield of 4.5 t/ha is a realistic attainable yield for the conditions prevalent in Alta Verapaz. More controlled experiments conducted in the region testing Zn sources have produced average yields greater than 5.5 t/ha (data not shown), which has become the target yield for the immediate future. It can also be assumed that, in general, grain yields of around 1.5 t/ha can be obtained without N and 2.5 t/ha without P. Finally, it can also be assumed an agronomic efficiency (AE) of 20 kg of grain/kg of N used and 40 kg of grain/kg of P used. These numbers can be used as a reference for corn production in the region until more accurate figures are obtained by research.

Better crop and nutrient management will increase yields and improve N and P AE. Nitrogen and P fertilizer rates were then calculated using the proposed figures as follows: rate = yield complete treatment minus yield of the omission plot/AE. Calculated fertilizer rates with the assumptions stated previously are close to those already utilized in the experiment: 150 and 90 kg/ha of N and P_2O_5, respectively. The difference is that there are concrete parameters for attainable yield and AE, which now need to be improved by better farmer management of the crop. This process will progressively fine-tune the fertilizer rates for the recommendation domain at Alta Verapaz. Improved crop and fertilizer management can lead to higher attainable yields, higher nutrient use efficiency, and a better returns for local farmers.

The corn program continued in the field during 2009 and 2010, utilizing the experience gathered in previous years. One of the main activities during this period was training. Training sessions were conducted to instruct old and new program technical staff in implementing the best management practices proven to be effective in farmer fields. Trained staff then instructed participating farmers and worked with them in the field at planting time. During the growing cycle, the differences between participating fields and traditional fields were evident. Just before harvesting, staff provides assistance to improve the seed selection and the training was reinforced, particularly on planting distances, pest and disease control, and nutrient management. A pilot project was implemented with support of ENCA (National School of Agriculture), to develop a reference manual for best management practices. The manual was distributed among technical staff and farmers. After harvesting, the program enables farmers to sell their corn at the best prices – accomplishing one of the main objectives of the program. The process to select new participants for the next season begins with the help of technicians and participant farmers alike.

Home Improvement Progress

HELPS International has been providing a home improvement program for several years in many poor rural areas. In many households of rural Guatemala and Central America, inadequate living conditions deepen the cycle of poverty. Approximately half of the people of rural Guatemala still cook on open fires in their homes. As a result, lethal levels of carbon monoxide can accumulate in the home. The number one killer of children under the age of 5 is pulmonary diseases contracted in homes with interior open fires. In addition, women must spend hours daily gathering wood or spend half their income to buy firewood, and then they have to tend these fires for 5 to 6 hours a day. These conditions represent a high risk for eye problems and even fatal carbon monoxide poisoning. Pregnant women can have low-weight babies with potential pulmonary problems.

Water filters have helped improve family health.

The HELPS International solution to this problem was the development of the ONIL Stove. It is a highly efficient design which allows cooking with a very small fraction of wood compared to an open fire. The health and environmental benefits

Dr. José Espinosa Retires, Dr. Raúl Jaramillo Named New Director of IPNI Northern Latin America Program

Dr. Raúl Jaramillo has been promoted to Director of the Northern Latin America (NLA) Program of the International Plant Nutrition Institute (IPNI) effective January 1, 2011. Dr. José Espinosa, who had served as Director of the NLA Program, retired effective December 31, 2010. The office for the Program is located in Quito, Ecuador.

In recent years, Dr. Espinosa also had responsibility for IPNI activities in Mexico and Central America. Dr. Armando Tasistro has been named Interim Director for Mexico and Central America. He joined the IPNI staff as Communications Specialist in 2009 and is based in the IPNI headquarters office in Norcross, Georgia, USA.

"We expect a smooth transition during this time and plan to maintain positive and productive programs in these important regions," noted IPNI President Dr. Terry Roberts. "Dr. Espinosa has accomplished significant and lasting advances for the agriculture and people of all the areas he served throughout his career. His positive influence extended to our programs worldwide."

In 1989, Dr. Espinosa joined the staff of the Potash & Phosphate Institute (PPI), the predecessor of IPNI. A native of Quito, he completed undergraduate training in agronomy at the Central University of Ecuador before earning his M.Sc. from Michigan State University in 1979 and his Ph.D. at the University of Kentucky in 1986. He later held important responsibilities with the National Institute of Agronomic Research (INIAP) in Ecuador and served as a consultant in soil fertility and crop management.

"Dr. Espinosa has set a high standard in his achievements, and he also produced an impressive record of practical and well-used publications, plus a network that delivers science to farmers throughout much of the region. The numerous awards and honors he has received are well-deserved and speak highly of his reputation for integrity," added Dr. Paul E. Fixen, IPNI Senior Vice President, Americas and Oceania Group, and Director of Research. "Because Dr. Jaramillo has the benefit of more than 2 years of experience as Deputy Director, IPNI programs will continue to progress."

Dr. Jaramillo, also a native of Ecuador, joined the IPNI staff in 2008. He completed undergraduate studies at Central University in 1994, then worked with the International Potato Center (CIP) before earning his M.Sc. degree at the Wageningen Agricultural University in Holland. Dr. Jaramillo completed his Ph.D. program at The Pennsylvania State University. His region now includes Peru, Ecuador, Colombia, Venezuela, Panama, Costa Rica, Dominican Republic, Puerto Rico, and Cuba.

Dr. José Espinosa retired from IPNI at the end of 2010.

Dr. Raúl Jaramillo became NLA Program Director January 1, 2011.

Dr. Armando Tasistro will serve as Interim Director for Mexico and Central America.

Dr. Tasistro, a native of Uruguay, received his Ph.D. in soil fertility in 1993 at the University of Georgia and was research scientist in the Agricultural and Environmental Services Laboratory there before joining the IPNI staff in 2009. He was with the International Maize and Wheat Improvement Center (CIMMYT) in Mexico from 1984 to 1993. BC

Guatemala corn *(continued)*

derived from the use of the ONIL Stove are impressive. With initial funding by the Shell Foundation, these stoves are now produced in two factories, one in Guatemala and one in Mexico. Currently, around 80,000 stoves have been implemented in Guatemala and Mexico. In addition to the ONIL Stove, other items to improve home quality of life are outdoor stoves, water filters, and solar light systems. Participants of the 2009 and 2010 Corn Programs were also involved with the home improvement program. Installation of stoves and water filters were an incentive for their commitment to the program. The experience HELPS International gained during the 2009-2010 corn and home improvement programs will be useful in providing a more integrated approach for better family living. Future steps in this integrated approach are better distribution of space in homes to keep adults and children in different rooms, and small vegetable gardens to provide better nutrition for the family and to teach basic agricultural practices. BC

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