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Strategic Investment in Rapid Technology Dissemination: Commercialization of Disease Resistant Bean Varieties in Guatemala, Nicaragua, Honduras and Haiti

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Executive Summary

The Bean Technology Dissemination (BTD) Project (Strategic Investment in Rapid Technology Dissemination: Commercialization of Disease-Resistant Bean Varieties in Guatemala, Nicaragua, Honduras, and Haiti) was contracted as an associate award to the Dry Grain Pulses CRSP (currently the Legume Innovation Lab) by the Bureau for Food Security, USAID. With a focus on increasing common bean productivity, the BTD Project was implemented by the Legume Innovation Lab in collaboration with subcontracted national institutions and other development partners to address the shortage of high quality bean seed available to resource-poor farmers in Guatemala, Nicaragua, Honduras, and Haiti.

Investments in bean varietal development and research on other productivity-enhancing technologies by the Bean/Cowpea and the Dry Grain Pulses CRSPs, including the use of *Rhizobium* inoculants, have been extensive in Central America and the Caribbean over the past few decades. Numerous improved common bean varieties, offering realistic promise of higher yields and improved food security for smallholder farm households, have been released by Ministries of Agriculture in countries in the region for commercial production. Regretfully, public sector and NGO-led efforts to make these technologies accessible to resource-poor farmers have not resulted in widespread adoption. The goal of the BTD Project was to disseminate high quality bean seed of genetically improved varieties preferred by farmers with multiple disease resistance and adaptation to the diverse agroecologies within the region to smallholder farmers.

The project provided five to 20 pounds of certified or quality-declared bean seed to 30,000 smallholder farmers in each of the countries. In certain countries, seed multiplication was conducted at the community level to build local capacity for seed production and keep seed production and distribution costs low. From the onset, a secondary objective of the BTD project was to address the constraint of dysfunctional seed systems for common bean in these countries and to test alternative seed multiplication models that might sustainably provide affordable quality seed to smallholder farmers.

Since Nicaragua, Honduras, Guatemala, and Haiti have different seed registration and certification policies, diverse public and private institutions involved in seed production and marketing, and farmer communities with distinct technical assistance needs, the BTD project designed unique dissemination approaches for the four countries. This approach required working with diverse partner institutions (NARS, National Extension Systems, agricultural universities, and NGOs) to implement the project.

Major achievements of the BTD project include the dissemination of 39 different genetically improved common bean varieties to more than 102,000 households and the establishment of an estimated 257 Community Seed Banks (CSBs) in Nicaragua, Honduras, Guatemala, and Haiti. Notably, 75 of these CSBs want to continue multiplying bean seed to meet the needs of their communities. Additionally, more than 20,500 packages of *Rhizobium* inoculant were produced for implementing partners and distributed with the seed. To enhance local capacity in seed production, hands-on community training was provided to thousands of farmers on seed production, conditioning, storage, and *Rhizobium* inoculant use.

The BTD project strengthened the capacity of the NARSs (DICTA, ICTA and INTA) to produce and handle registered bean seed and to provide technical assistance to seed producers, enabling these institutions to more effectively support the development of informal private sector seed production in the future. Additionally, the Bean Program at EAP-Zamorano was able to increase production of foundation seed of more than 15 improved bean varieties. As a result, the NARSs' reputation has greatly improved as a dependable source of quality seed of high yielding preferred varieties of common bean.

Committed to ensuring gender equity in the selection and accessibility of dissemination technologies, BTD Project partners encouraged active participation by women in training events and the leadership of CSBs. In Nicaragua, 21 percent of CSB participants were women, in contrast to 58 percent in the Guatemalan highland CSBs and 25 percent of CIAL members in Honduras. In fact, several CIALs were exclusively organized and led by women, and approximately 50 percent of the laborers in production, conditioning, and packaging of seed were women. Finally, in Haiti, more than 25 percent of seed recipients were women farmers.

The BTD project succeeded in disseminating seed of improved bean varieties with the quality, quantity, and timeliness required to meet farmers' planting needs and schedules. It readily became evident, however, that distribution of technologies to smallholder farmers living in remote rural areas over a highly diverse agroecological landscape within a country, and thus with different bean growing seasons, presents significant logistical, handling, transportation, communication, and timing challenges. Many of these challenges are ameliorated, however, when seed is produced locally.

Assessments of the seed system models in Nicaragua, Honduras, and Guatemala provided important insights into factors contributing to success and sustainability, and how future seed dissemination initiatives might be more effectively designed. Strong capacity and technical expertise in seed production by NARS plus the ability to produce and distribute high quality seed (disease free, genetically pure, with high germination and vigor) were found to be strengths of the BTD project. Weaknesses included insufficient partner training, limited farmer access to technical assistance on integrated crop management, and in a few cases, late seed delivery.

The assessment study also determined that the most significant contribution of the BTD project to advancing sustainable seed systems was accomplished in Nicaragua, where an informal community-based seed multiplication model (a Community Seed Bank) was being promoted by INTA. Partnership in BTD enabled INTA to focus on common bean seed production and on scaling-up CSBs within the country in a serious way, establishing CSBs in 200 communities. Building upon the experiences gained in Nicaragua, BTD provided the platform to promote and extend the CBS model to Guatemala and Honduras during years two and three of the project. In Haiti, where project execution conditions were difficult, the community-based seed multiplication and dissemination model was only tested in two locations during the final year of the project—with successful results.

The BTD project offers a strong foundation of experiences to confidently propose that the CSB model can be uniquely effective for sustainable seed multiplication of common bean and other self-pollinated grain legume crops produced by resource-poor, smallholder farmers in other cultural and agroecological contexts (e.g., East Africa, West Africa). The unquestioned benefits of planting disease-free seed with high germination and genetic potential clearly justify and provide incentive for leader farmer and farmer organization involvement in seed production to supply seed for smallholder farmers within a locality. Although economic factors (e.g., access to credit for inputs) and other incentives may vary from one context to another, evidence from the BTD project clearly demonstrates that grain legumes are unique from other direct seeded agronomic and horticultural crops and that trained farmers can successfully produce and store quality grain legume seed. Community and farmer ownership of local seed production, however, were found to be critical for the sustainability of informal grain legume seed production. The importance of seed can be readily appreciated by most farmers and serves as an incentive once seed security is linked to the productivity and resilience of the cropping system.

List of Abbreviations

BTD	Bean Technology Dissemination Project
CAU	Comite Agrícola Unitario
CIALs	Comités de Investigación Agrícola Local (Local Agricultural Research Committees in Honduras)
CIAT	Centro de Investigación Agrícola Tropical, Cali, Colombia
CRS	Catholic Relief Services
CRSP	Collaborative Research Support Program
CSB	Community Seed Banks
Cwt.	Hundredweight (sacs of 100 pounds.)
DICTA	Dirección de Ciencia y Tecnología Agropecuaria-Honduras
DR	Dominican Republic
EAP	Escuela Agrícola Panamericana-Zamorano, Honduras
FIPAH	Fundación para la Investigación Participativa con Agricultores en Honduras
FTF	Feed The Future
FUNDIT	Fundación para la Innovación Tecnológica, Agropecuaria y Forestal
FY	Fiscal Year
ICTA	Instituto de Ciencia y Tecnología Agrícolas, Guatemala
IDC	Indirect Cost – rate
IICA	Inter-American Institute for Cooperation on Agriculture
INTA	Instituto Nicaragüense de Tecnología Agropecuaria, Nicaragua; also, National Bean Research Program of Nicaragua
M&E	Monitoring and evaluation
MO	Management Office

MSU	Michigan State University
MT	Metric Tons
NARS	National Agriculture Research Service
NGO	Nongovernmental Organization
NSS	National Seed Service – Haiti
PDT	Plot planted with 20 pounds of seed used for technology dissemination, Nicaragua
PRR	Program for Rural Reconstruction, Honduras; also Programa de Reconstrucción Rural
Pulse CRSP	Dry Grain Pulses Collaborative Research Support Program
SNEA	Sistema Nacional de Extensión Agrícola– Guatemala
SOW	Scope(s) of Work
UNISEM	Unidad de Semilla – INTA, Nicaragua
UPR	University of Puerto Rico
USAID	United States Agency for International Development
WV	World Vision

Introduction: Project Justification

This is the final technical report of the Bean Technology Dissemination (BTD) Project (Strategic Investment in Rapid Technology Dissemination: Commercialization of Disease-Resistant Bean Varieties in Guatemala, Nicaragua, Honduras, and Haiti). With funding from Feed the Future, Bureau for Food Security, USAID, and collaboration with national institutions and other development partners, the BTD Project was implemented by the Legume Innovation Lab to address the shortage of high quality bean seed available for resource-poor farmers in Guatemala, Nicaragua, Honduras, and Haiti. This report will focus on the outputs and outcomes realized during the three-and-a-half-year project that began in October 2010 and was completed in March 2014.

High poverty rates, chronic food insecurity, and widespread malnutrition in Guatemala, Honduras, Nicaragua, and Haiti provided the impetus for this project. In addition to ongoing poor crop yields from traditional landraces, natural disasters (e.g., flooding due to hurricanes and earthquakes in Haiti) and risks associated with climate change have further contributed to the low productivity of maize and beans under traditional production systems. Given the importance of these two crops in the diet, low production has resulted in high food insecurity. Since common beans are grown and consumed widely in all of these countries, increasing agricultural productivity was a direct and reasonable answer to many of the food security concerns in this region. Rural households would benefit from technology that increase crop yields, provide greater household food stocks and, potentially, generate increased household income. Increasing the availability of highly nutritious grain legumes in domestic markets at affordable prices would also contribute to improvements in the nutritional value of diets throughout the region—in both rural and urban areas.

Investments in bean varietal development and research on other productivity-enhancing technologies, including the use of inoculants, have been extensive and successful in these regions over the past several decades. Despite these technological advances for increasing yields, crop yields among rural agricultural households have remained low because farmer access to these technologies has been stymied. To reap the benefit of the improved varieties that have been developed require getting these to the farmers to plant. However, seed systems are poorly developed in the region and the distribution of these improved varieties has been limited. Thus, farmers who could positively profit from agricultural growth through these genetic materials have been unable to access improved seeds and often lack the information and capital for acquiring productivity-enhancing inputs that could contribute to increasing bean productivity. Because all of these, the challenge was not just increasing bean productivity using available improved varieties but ensuring that sustainable systems were developed for technology transfer over time, especially for improved varieties, so that these available technologies could be reliably accessed and used by the resource-poor farmers who need them.

The key strategy [to increase productivity of basic grains] was facilitating access to already available technologies. . . . Many improved pulse varieties for these regions already offered realistic possibilities of improving food security, but the improved varieties weren't getting to farmers for planting.

The Feed the Future (FTF) implementation plans for USAID Missions in Guatemala, Nicaragua, Honduras, and Haiti identified a strategic focus to increase productivity of basic grains (including dry grain pulses/beans) and ensure farmer resilience to crises: **Access**. The key strategy was facilitating *access* to already available technologies to ensure that farmers could use them. Many improved pulse varieties for these regions already offered realistic possibilities of improving food security, *but the improved varieties weren't getting to farmers for planting*, resulting in landrace varieties continuing to yield low crop quantities, and the cycle of low yields consistently creating food and nutrition insecurity.

Based on its long history of engagement in the region with the Dry Grain Pulses Collaborative Research Support Program (Pulse CRSP) (2007–2012) and its predecessor, the Bean/Cowpea CRSP (1980–2007), Michigan State University (MSU) was well situated to address the challenge of bean technology dissemination. Through these CRSPs, strong collaborative ties had already been established with the National Agriculture Research and Extension Systems (NARS), universities, NGOs, farmer associations (including local agricultural research committees—CIALs), and private sector organizations that provide support services to the bean sector. These relationships and a firm understanding of the bean sector in Honduras, Guatemala, Nicaragua, and Haiti were essential to the design and implementation of the BTB Project activities in the region.

Project Goals

The BTB Project was designed to alleviate food deficiencies in these regions by addressing the shortage of high-quality bean seed of improved varieties for planting to resource-poor farmers, to ensure increased bean productivity. Delivery of these improved varieties served as the means to ensure increased crop yields.

The foundational goal of the BTB Project was achieved through the following objective:

- To make quality seed of improved varieties of beans plus nitrogen fixing *Rhizobium* inoculants accessible to resource-poor farmers in food insecure areas so as to increase farm productivity, profitability, and sustainability.

The project provided farmers with small quantities (five to 20 pounds) of affordable quality seed with the expectation that these seeds would be multiplied, stored, and shared with others members of the community. Access to good quality seed at the farm and community levels would then translate into increased crop yields and improved household food security. As the dissemination objective was being pursued and achieved, however, it became increasingly apparent that ensuring dissemination of quality seed for the long-term required that another objective be incorporated into the project's design:

- To implement a sustainable bean seed system with local farmer and community involvement to ensure long-term availability of quality seed of improved varieties at affordable prices for resource-poor farmers that will continue after the termination of this three-year project in each of the four countries.

Why is There no Private Sector Participation in Legume Seed Systems in BTD Target Countries?

A common question from stakeholders is why the private sector has not been taken advantage of such wealth in improved genetic materials for beans, as in the cases of maize, rice, and other horticultural crops. The answer is not simple and needs to be considered from many angles.

From a marketing standpoint, there is little incentive for the private sector to cater to an audience vastly comprising poor farmers with very small landholdings who are vastly dispersed geographically.

From a product characteristics standpoint, estimating annual demand for a self-pollinated crop such as beans is difficult since many farmers choose to save their own grain as seed or borrow grain from family or neighbors when they are unable to save their own. While this practice is the ancestral way of keeping seed in legume crops, farmers' harvests are not always healthy; consequently, this practice often contributes to the spread of seed-borne diseases, leading to low yields and contributing directly to the cycle of household food insecurity and poor nutrition. This practice significantly discourages the private sector, which prefers to disseminate seed that farmers need to buy every year, such as hybrid maize and certified seed of high-value horticultural crops. Finally, the amount of bean seed needed per hectare is large, heavy and voluminous, adding to the costs of logistics (transportation and storage) that large or small agricultural depots need to incur to make seed available at the community level. For example, maize is planted at a rate of 15–20kg/ha while beans need three times more to cover the same area (45–60kg/ha).

The existence of improved varieties would yield nothing if the seed system in place were unable to guarantee the availability of these varieties for ongoing farmer use. As mentioned earlier, that is what happened with many high performance varieties, some of them developed decades ago. NARS have been remarkable collaborators in the development of new bean varieties because they have recognized the importance of beans in the food security of smallholder agrarian systems since the 1970s. NARS scientists—some of the best and most senior were involved with the BTD project—have accumulated decades of experience in collaborating with CRSP, CIAT, and a long list of associated research partners. Such high-quality human resources paired with their installed capacities (experimental stations with land, irrigation, labor, etc.) to conduct trials have resulted in the release of more than 60 varieties of black and red bean types for the region since the early 1980s. In the meantime, anecdotal evidence indicates that in Guatemala, less than 3 percent of circa 4,000 hectares

planted with beans during the BTD project year used improved varieties. The proportions for Honduras and Nicaragua could be higher due to more integrated seed systems, but it is. The conclusion is that the research and development of new varieties have done their part, but resources to disseminate these improved varieties were needed to realize the value of these improved varieties in the fields of smallholder farmers and their communities.

Ideally, dissemination should be the work of a rural extension system that brings validated technologies to smallholder farmers to see, try, and eventually, adopt. However, government-led extension systems in target countries ache from lack of resources and most are easily disrupted by changes in government that affect the availability of funding for personnel salaries and logistical support. NGO-led programs often play the role of government extension services, but their initiatives are often short-lived or have limited time horizons to accompany farmers in the adoption process through several production seasons—a limitation that makes farmer access to technologies unreliable and which ultimately lacks long-term impact. The private sector’s role in legume seed systems is absent or weak for reasons explained in Text Box 1. Therefore, to achieve some sustainability in seed systems, it is necessary to combine the strengths of all actors in the value chain (NARS, NGOs, and other support organizations).

The BTM Project accomplished this multipartner integration, greatly increasing the dissemination of 39 improved varieties and virtually assuring greater food security in these vulnerable areas. Further, the project not only increased improved seed distribution and crop productivity but, more importantly, provided evidence of strengths and weaknesses of the overall design of the bean seed systems in these target countries. Interacting with the major actors in these seed systems along the project implementation has provided important lessons for similar interventions in the future. Details on the activities performed, the results achieved, and the lessons learned are described in this report, with particular emphasis on how the Legume Innovation Lab learned from this effort to advise USAID and other donor-led programs to contribute to the sustainability of seed systems.

Approaches and Methods

Working with four different countries demanded four different approaches that took into account different sets of seed system actors, seed production policies, and political priorities in the agricultural sectors. From the start, the BTM Project realized that a tailored country-by-country program was necessary to address the needs of diverse bean farmer populations with different improved variety needs adapted for specific regions during different planting seasons. Briefly (with greater detail provided later in this report), each of the country’s seed system is outlined below.

Guatemala

In Guatemala, the seed multiplication and distribution model was centered on the public and NGO sectors playing a major role throughout the seed value chain—from contracting with seed multipliers to delivering the seed into the hands of beneficiaries/farmers. National Agriculture Research Services (NARS) such as ICTA have the advantage of employing long-term personnel, unlike short-term projects run by NGOs or other public sector institutions in Guatemala, such as the National Agriculture Extension Service. Because of such changes in the array of partners disseminating seed to targeted areas every year, this model had to be flexible and relied on the long-term relationships established by ICTA to reach remote communities.

**BTD Project Management
Accountability**

Regional coordination, constant communication, transparency, sharing of lessons learned from one country to another, and both in-country and Management Office programmatic monitoring were essential for working with the diverse partner institutions (NARS, National Extension Systems, agricultural universities, and NGOs) and effective implementation of the project across areas.

Honduras

In Honduras, the model used was led by a private university (EAP–Zamorano), with the collaboration of the national agriculture research service DICTA. In the case of EAP–Zamorano, the responsibility for seed multiplication and distribution relied on CIALs creating a community-based model similar to Community Seed Banks (CSBs) and providing seed to community members at affordable prices throughout the project implementation. For DICTA, seed multiplication during Years 1 through 3 relied on qualified microenterprises that then sold the apta seed to DICTA for dissemination in different communities. An important departure from this model for DICTA was the establishment of 35 CSBs following the experiences of INTA in Nicaragua.

Nicaragua

In Nicaragua the seed multiplication and distribution model was based on Community Seed Banks. The seed bank model operates on do-it-yourself principles in which community members come together to multiply seeds to meet their own community's current needs, save seeds for future seed security, and sell excess seeds to generate revenues to cover

their production costs. The national bean research program of Nicaragua (INTA), through its network of regional offices, played an important role in supplying the registered seed stocks of improved varieties to community seed banks and providing technical assistance to ensure that the seeds produced by the seed bank met minimum quality standards as planting materials.

Haiti

The project initially tried to use a dual approach involving both private and public sectors, with the public sector (National Seed Service [NSS]) supplying registered seed and supervising seed multiplication fields, the private sector then selling the seeds through retail outlets and the public sector distributing seeds to resource-poor farmers. Due to poor private-sector performance in multiplying the expected quality seed in amounts needed by the project, this approach did not work. Multiplication at NSS-operated multiplication fields was limited due to adverse climatic conditions and available area. Changes were necessary in the following years. With two years left in the project, the alternative model adopted involved sourcing certified seed from the Dominican Republic and then disseminating it through a network of NGO collaborators based in the bean producing areas of the country. It was not until the last year that a CSB-based model was implemented with two grassroots organizations. During the last month of the BTD Project's operation, it was confirmed that these two organizations succeeded in producing high quality apta seed. Details on seed dissemination results were unknown at the time this report was finished.

These different approaches, which involved farmers and several development organizations in various roles, were reflected in the Scopes of Work (SOW) developed for each of the seven subcontracted institutions. Regional coordination, constant communication, transparency, sharing of lessons learned from one country to another, and both in-country and Management Office (MO) programmatic

monitoring were essential for working with the diverse partner institutions (NARS, National Extension Systems, agricultural universities, and NGOs) and effective implementation of the project across areas. Details of the projects' partnerships and how all of the partners contributed to implementing seed systems will be examined in the next section.

The MO placed high priority on implementing the BTM Project in a manner that contributed to the establishment of sustainable bean multiplication and dissemination systems in each country; this priority was well thought out, since these systems have continued to operate even with the project complete. Even in Haiti, where implementation conditions presented a different order of challenges, the sustainability goal was given equal priority as in other countries. The results in Haiti are encouraging as two grassroots organizations will continue the BTM work in two of the country's most important production zones.

Project Partnerships

Guatemala

Fundación para la Innovación Tecnológica, Agropecuaria y Forestal (FUNDIT)

FUNDIT was the principal subcontractor for the BTM Project in Guatemala. FUNDIT is a private foundation established to manage external, donor-funded projects for ICTA and other entities within Guatemala's Ministry of Agriculture to ensure financial and technical integrity and effective project implementation.

FUNDIT subcontracted and worked with ICTA personnel to ensure that activities were carried out in accord with annually developed scopes of work and budgets. FUNDIT monitored and promoted communication between ICTA and more than six support NGOs and government offices in the field to achieve effective coordination and implementation of all activities. In the absence of a strong ICTA presence in the field, the dissemination goals of the BTM Project in Guatemala were reached because of such coordination with multiple organizations.

FUNDIT was responsible for the reporting of technical progress, the achievement of specific mutually agreed-upon deliverables, and for invoicing MSU so that project execution expenses by ICTA and SNEA were received in a timely manner.

FUNDIT's specific contributions to the success of the BTM Project are summarized in the points below.

- Timely and transparent management of financial resources channeled to ICTA and SNEA for project execution,
- Reliability in addressing project emergencies concerning payments to seed suppliers and access to credit for inputs and services (bags, labels, seed freight services, etc.);
- Timely delivery of performance reports and beneficiary databases.

Institute of Agricultural Science and Technology (ICTA)

The Instituto de Ciencia y Tecnología Agrícolas (ICTA) is the public institution responsible for carrying out research to produce genetic materials and to develop improved integrated crop management practices to increase agricultural productivity, promote the use of technology at the farmer level, and stimulate regional rural development. The impact of ICTA programs on domestic food security in Guatemala has

been highly praised in past years due in part to the release of improved bean varieties with excellent yield potential and resistances to the economically significant biotic and abiotic constraints in the various bean production regions of Guatemala. ICTA's strong institutional ties and knowledge of the bean sector in Guatemala were highly valuable in implementing the project. ICTA's specific contributions to the success of the BTB Project are summarized in the points below.

- Knowledgeable and responsible human resources to champion the different tasks associated with supervising and enforcing strict seed production protocols;
- Knowledgeable and experienced human resources to develop training curricula and deliver training on bean production to collaborating public sector institutions and NGOs;
- Committed senior and midlevel management to follow and execute project plans to help remote rural beneficiaries, most of whom accessed improved bean seed varieties for the first time;
- Rapid response to emergencies whenever organizational challenges arise, with multiple partners to meet project goals and objectives.

Honduras

Escuela Agrícola Panamericana (EAP–Zamorano)

EAP–Zamorano assumed a strategic technical leadership role for the BTB Project in the Central American Region and Haiti as well as within Honduras. For nearly 30 years, the Legume Innovation Lab (formerly the Bean/Cowpea and Dry Grain Pulses CRSPs) has partnered with and supported the Programa de Frijol (Bean Program) at Zamorano. As a result of CRSP's investments in the genetic improvement of small red and black bean market types, improved varieties are currently registered in all Central American countries and Haiti for commercial production. It is these CRSP varieties that needed to be promoted and made accessible to resource-poor, smallholder bean farmers in the region to enhance productivity. The genetic potential of these bean varieties also justified funding for this project.

In addition to its responsibilities for the coordination, planning, and implementation of bean seed multiplication and dissemination activities in certain regions of Honduras, EAP–Zamorano worked with Programa de Reconstrucción Rural (PRR) and the Fundacion para la Investigacion Participativa con Agricultores en Honduras (FIPAH), two grassroots organizations with resources committed to the bean seed systems in Honduras. EAP–Zamorano's specific contributions to the success of the BTB Project are summarized in the points below.

- Provision of genetic and registered seed stocks of most BTB-disseminated varieties that marked the beginning of the process in producing the expected quality seed in the project countries.
- Knowledgeable and committed senior human resources engaged in all BTB Project components locally in Honduras and regionally in the other three countries.
- Swift and effective use of project resources to address bottlenecks in meeting seed multiplication goals.
- Provision of facilities and resources to empower DICTA, ICTA, INTA, the University of Haiti and NGOs in multiplying *Rhizobium* inoculum locally.
- Coordination with PRR and FIPAH to support CIALs elevating their capacities to address the quality, volume and timely demands for apta seed in the target communities. CIALs that worked

with the BTD are now stronger and some of them are generating profits from the seed multiplication and dissemination activities.

Dirección de Ciencia y Tecnología Agropecuaria (DICTA)

DICTA operates within the Secretariat de Agricultura y Ganaderia in Honduras and has a national government mandate to generate and to transfer technologies designed to increase agricultural productivity. Under strong collaboration with EAP–Zamorano, DICTA demonstrated its project management capacity to achieve the objectives of scopes of work in a timely, transparent, and effective manner. DICTA’s direct involvement was necessary to address areas of the country where EAP–Zamorano had less comparative advantages, particularly in four areas of the country where DICTA has strong institutional presence.

DICTA has been successful in introducing improved bean varieties with high genetic value and disease resistance in communities previously unreached in rural Honduras. Although the DICTA model still depended on purchased seed from qualified multipliers, DICTA visited the BCS experience in Nicaragua and undertook the establishment of 35 such banks in Honduras. DICTA has been a firm believer in the sustainability of community-multiplied bean seed in response to national efforts to achieve food security and better nutrition for rural populations. DICTA’s specific contributions to the success of the BTD Project are summarized in the points below.

- Knowledgeable and committed human resources to the management of the project.
- Transparent and timely execution of financial resources.
- Strong willingness to try new alternative models to achieve seed security.
- Ability and willingness to reach remote communities where no one had introduced seed of improved varieties before.

Nicaragua

Instituto Nicaragüense de Tecnología Agropecuaria (INTA)

A public sector institution with many years of experience, the Instituto Nicaragüense de Tecnología Agropecuaria (INTA) is the national authority within Nicaragua for both agricultural research and providing technical assistance to communities of farmers. The BTD Project worked with INTA’s five regional offices, which operated with a high level of interdependency, to customize technical assistance to meet different needs and accommodate different microclimates throughout the country. INTA shared the BTD Project’s vision of providing access for resource-poor, smallholder farmers to high quality bean seed of improved varieties to increase yields, produce high quality grain demanded by domestic markets, and increase their income so as to improve their quality of life. INTA’s specific contributions to the success of the BTD Project are summarized in the points below.

- Institutional commitment to co-invest with the BTD Project in the establishment of more than 200 BCS;
- Knowledgeable and committed human resources to manage the project, motivating INTA staff in five different regions to believe in the BCS model and support it;

- Although not all project resources assigned to INTA were executed on time, it was evident that the project managed financial resources transparently and cost-shared much of the project activities to organize BCS in the different regions.

Haiti

University of Puerto Rico (UPR)

UPR–Mayagüez has been a strong institutional partner with the Legume Innovation Lab for many years, generating and releasing improved bean varieties for the lowland tropics that are characterized by high temperatures and heavy rainfall. In Haiti, UPR partnered with EAP–Zamorano Honduras and the National Seed Service at the Haitian Ministry of Agriculture in Haiti. UPR played an important role in conceptualizing the BTD Project, including the preparation of the Technical Application submitted to USAID. Additionally, UPR brought significant expertise on the production and use of *Rhizobium* inoculants to enhance nodulation and biological nitrogen fixation in bean production systems. As a result, the BTD Project validated a number of *Rhizobium* strains for the diverse agroecological areas in Haiti and trained local technicians on the production of inoculants. UPR’s specific contributions to the success of the BTD Project are summarized in the points below.

- Active participation of senior scientists that understand the development challenge that BTD addressed,
- Rapid availability of human resources to respond to knowledge gaps and training needs in the country;
- Regional leadership in the development of *Rhizobium* inoculum multiplication and training capacities at the local level;
- Commitment to sustainability by engaging with a cadre of different collaborators interested in improving seed systems in Haiti;
- Timely and transparent use of financial resources to achieve program goals and objectives.

National Seed Service (NSS)

As a long-term institutional partner in the Bean/Cowpea and the Pulse CRSP (and now the Legume Innovation Lab), NSS has been key to accomplishing the project activities under Haiti’s Ministry of Agriculture . NSS has a governmental mandate for the testing, certification, procurement and dissemination of improved seed varieties of staple crops including beans. NSS collaborated with the supervision of seed production protocols in accord with national seed production laws and regulations. NSS staff has been championing activities in Haiti in close collaboration with UPR and EAP–Zamorano for 40 years, making it a natural partner for this initiative. NSS-specific contributions to the success of the project are listed below.

- Experience in the design of alternatives to improve the project’s production and dissemination strategy;
- Commitment of its most senior scientist with knowledge and expertise of the region’s most promising varieties possessing high adaptability and yield potential in Haiti.
- Access to a network of NGO collaborators that made it possible to reach remote areas in the country.

Inter-American Institute for Cooperation on Agriculture (IICA)

IICA's long-term presence in Haiti has allowed it to cultivate close relationships with several offices of the Haitian Government, particularly the National Seed Service (NSS) in seed production programs. IICA's involvement in the administration of ProFrijol, a CIAT-led regional bean network and other seed projects financed by the Canadian and Argentinian governments, motivated the BTD team to select IICA as a partner to provide leadership for project activities in Haiti. IICA had the institutional stature within Haiti to oversee and monitor the implementation of BTD Project activities of the NSS, and of private sector partners and NGOs. IICA's linking with the Ministry of Agriculture agencies was vital to BTD because subcontracting with NSS was not possible despite different trials. Although the BTD management collaborated directly with NSS, IICA worked as a strong link to engage NSS in the supervision of seed production protocols in accord with national seed production laws and regulations. IICA's specific contributions to the success of the BTD Project are summarized in the points below.

- Committed senior and midlevel management to meet project goals and objectives.
- Knowledge of the local public sector policies and interests that help plan project activities aligned to these national institutional priorities.
- Timely and transparent management of project resources to achieve project goals, particularly in connection with NSS.

Major Project Achievements

The following sections summarize the project's major achievements. A summary of achievements, including additional details on different project indicators is also provided in Table 1.

Reaching Farmers with Seed of Improved Varieties

The BTD Project was designed with the aim of making production and distribution of quality declared seed of improved varieties that had been developed in the target countries, but were poorly disseminated. Most farmers reached by the project were able to use this seed of improved varieties for the first time even when such varieties were developed in the 1980s and 1990s. Although it sounds simple, achieving dissemination goals implied a multifaceted effort from committed partners in each country to secure land for seed multiplication, train seed producers and inspect seed multiplication lots to ensure quality, and devise the most cost-effective logistics to reach farmers in remote areas.

Table 1. Cumulative results of the BTD Project’s bean seed dissemination efforts in Guatemala, Honduras, Nicaragua, and Haiti, October 2010–March 2014

Achievement	Year 1 (2010–11)	Year 2 (2011–12)	Year 3 (2012–14)	Cumulative (2010–14)
Number of smallholder farmers reached with quality seed of improved bean varieties				
Guatemala	4,998	7,364	20,980	33,342
Honduras	4,334	5,980	15,686	26,000
Nicaragua	5,385	4,966	5,714	16,065
Haiti	0	9,077	17,563	26,640
Total	14,717	27,387	59,943	102,047
Quantity of seeds of improved bean varieties disseminated to farmers (MT)				
Guatemala	45	37	95	177
Honduras	42	53	42	137
Nicaragua	63	59	46	168
Haiti	0	21	40	61
Total	150	170	223	543
Area cultivated with the improved bean varieties (Hectares)				
Guatemala	114	93	238	445
Honduras	104	132	105	341
Nicaragua	157	147	115	419
Haiti	0	52	100	152
Total	375	424	558	1,357
Number of improved bean varieties disseminated per year				
Guatemala	2	3	4	
Honduras	18	17	24	
Nicaragua	1	3	6	
Haiti	1	2	2	

Source: Individual BTD Country Reports

Different lessons were learned on how to carry out these activities better; and strengths and weaknesses have been systematically assessed in at least three countries.¹ At the end, the project's management team is satisfied to report that the intended goals and objectives have been achieved which contribute to more expanded and sustainable seed systems. The numerical outcomes are summarized below.

- At least 39 different improved varieties were disseminated in the four target countries to more than 102,000 households.
- At least 257 Community Seed Banks have been established in Nicaragua, Honduras, Guatemala, and Haiti.
- At least 75 CSBs have expressed their intention to continue supplying seed of improved varieties in their respective communities.

Rhizobium Inoculum Dissemination

The BTB Project led several efforts to disseminate in the four target countries. It is known that common beans can nodulate and fix nitrogen with the *Rhizobium* species *R. tropici*, *R. leguminosarum* bv. *Phaseoli*, and *R. etli*; however, soil *Rhizobium* strains vary in their ability to fix nitrogen and certain strains are more effective than others. In Haiti, for instance, root nodules on bean plants are usually present in low numbers while in Central America, similar nodulation is observed, particularly in dry areas. Inoculation with efficient strains has the potential to increase dry matter and grain yields. Although for the BTB Project it was not possible to evaluate the *Rhizobium* inoculum's impact in a systematic manner, grower and technician accounts in different countries, particularly in Honduras, Haiti, and Nicaragua, indicated that it was a worthy investment.

In Central America more than 20,500 packages of *Rhizobium* inoculant (between 20g and 50g, depending on the country) were produced for project collaborators in Honduras (DICTA and NGOs), Nicaragua (INTA), and Guatemala (ICTA). These doses were distributed along seed dissemination efforts. More than 20 technical personnel from Honduras (DICTA and NGOs), Nicaragua (INTA), Guatemala (ICTA), and Haiti (NSS, NGOs, and the University of Haiti) received training in *Rhizobium* technology and inoculant production. These trainings led to ICTA being self-sufficient in multiplying its own inoculum for the first time in 2013; in Haiti one NGO, Zanmi Agrikol, has been provided with the technical assistance and basic utensils to multiply it locally. DICTA in Honduras has also acquired funding from other sources to establish a functional *Rhizobium* inoculum multiplication facility, and BTB-trained personnel will make it operational.

Hands-on training offered by DICTA and NGO technicians at the community level on seed production, conditioning, and storage; *Rhizobium* inoculation; and organic fertilizer (bokashi, compost) production

¹ Byron Reyes, David DeYoung and Mywish Maredia. 2014. Effectiveness of the bean seed dissemination models implemented under the Bean Technology Dissemination (BTB) Project: Results of key informant interviews in Guatemala, Honduras and Nicaragua Draft report to the Bean Technology Dissemination Project. Legume Innovation Lab, Michigan State University.

and use contributed to a significant increase of crop productivity in farmer seed production plots and commercial and subsistence bean production plots.

In summary, the BTB Project was successful in strengthening ties between the NARSs and hundreds of community-based organizations. NARSs will capitalize on these experiences to continue their work in improving the national bean seed systems and working with other crops.

Table 2. Rhizobium production and dissemination in BTB countries

Country	Kg	Doses (25, 30 and 100g)	Beneficiaries
Haiti	695	9265	8,536
Nicaragua	600	12000	11,600
Honduras	60	1200	1193
Guatemala	120	1600	1600
Total	1475	24065	22929

Source: BTB Country Reports

Specific Country Results Highlights

Guatemala

Seed production began in Year 1 with 22.5 MT of ICTA Ligeró and 22.5 MT of ICTA Peten, with dissemination activities in the departments of Jalapa, Jutiapa, Chiquimula, Santa Rosa, and Peten. In these regions, 202 communities in 32 municipalities were reached with 4,998 households benefitting from 20 lbs of seed each.

During Year 2, production of 10 MT of ICTA Ligeró, 21 MT of ICTA Hunapú, and 7.5 MT of ICTA Peten were disseminated in the departments of Jutiapa, Santa Rosa, Izabal, Chimaltenango, Jalapa, Escuintla, Quetzaltenango, San Marcos, Solola, Quiché, Suchitepequez, Retalhuleu, Huehuetenango, Peten, Totonicapán, and Baja Verapaz. In total, 430 communities and 102 municipalities benefitting 7,364 farmers were reached—reflecting increases of approximately 300 percent, 200 percent, and 50 percent in municipalities, communities and farmers, respectively, over Year 1. It should be noted that producers in the Guatemala Western Highlands (San Marcos, Totonicapán, Solola, Quiché, and Huehuetenango) only received 10 lbs versus 20 lbs of seed because their land tenure is much less than in other areas of the country.

During Year 3, seed production was increased to 25.3 MT of ICTA Ligeró, 11.2 MT of ICTA Peten, 35 MT of ICTA Sayaxché, and 19.3 MT of ICTA Hunapú. The departments reached were Chimaltenango, Solola, Quiché, Huehuetenango, Totonicapán, San Marcos, Jutiapa, Chiquimula, Jalapa, Santa Rosa, Peten Suchitepéquez, where 117 municipalities benefited 21,040 farmers. Again, the number of beneficiaries increased substantially—almost 300 percent—over the previous year.

Lessons learned

- The allocation of seed per household needs to be customized to specific land tenure characteristics on a department or regional basis. Experience showed that 20-pound bags of certified seed of ICTA Ligerero and ICTA Peten were ideal for the department of Peten due to land tenure being the highest per household compared to the rest of country. Changing 20 pounds (9.1kg) to ten pounds (4.5kg) per bag for the west of the country was positive since farmers have little land. This change avoided wasting high-quality seed and reaching many more households.
- Agricultural extension workers were an important resource for the implementation of dissemination activities, but these professionals lack job security and are not present all the time. Training efforts should be concentrated on identified leader farmers with experience in bean production since they remain in the community and can thus easily share their knowledge with other farmers.
- In Guatemala some communities organize naturally, while others do not tend to work this way for various cultural, ethnic, or socioeconomic reasons. More time needs to be spent designing a CSB model adapted to one or two producers who can supply the improved bean seed to the community without needing to organize a fully integrated committee, as learned in the Nicaragua model.

Honduras

EAP–Zamorano was responsible for the national BTD program working closely with DICTA. Additionally, EAP–Zamorano worked with two leading grassroots organizations, PRR and FIPAH, to benefit thousands of smallholder bean producers with access to improved bean varieties. In Honduras, field visits to evaluate the need for technical assistance and training to support seed production and distribution activities under DICTA were also carried out.

EAP–Zamorano managed financial resources to support the seed multiplication and dissemination efforts by PRR and FIPAH and partnered with other organizations that had a long tradition of collaboration with small farmers, such as CRS and CARE. Several monitoring field trips included visits to seed production plots, seed conditioning facilities at CIALs, and collaborating institutions. During these visits, recommendations were given to collaborators and farmers in regard to seed production practices, seed conditioning, and storage; *Rhizobium* technology and inoculant use; and the use of organic fertilizers. Some of these visits were specifically planned with collaborators to provide technical assistance and training in the field. Partner organizations participating in the project activities coordinated by Zamorano in Honduras during FY12 included the Program for Rural Reconstruction (PRR) at the Yojoa Lake (municipalities of the departments of Comayagua and Santa Bárbara); the Foundation for Participatory Research with Farmers of Honduras (FIPAH) in the municipalities of Yorito, Sulaco, and Victoria (Yoro department), and in the municipality of Vallecillo (department of Francisco Morazán); Catholic Relief Services (CRS) and World Vision (WV) in the municipalities from the western region (departments of Lempira, La Paz, and Intibuca); and CARE/CIAT in municipalities from the southern region (Morazán and Choluteca).

While Zamorano multiplied basic into apta² seed through different partner-organized CIALs, DICTA multiplied foundation seed stocks at their own fields and contracted the multiplication of apta seed to lead farmers. Contracts were required to ensure that the seed multipliers used critical inputs (fertilizer, etc.) and that the seed would be purchased by DICTA at the time of harvest. This arrangement was accepted by DICTA contingent upon the provision of high quality seed by the farmers. Table 4 outlines the partners involved in seed multiplication.

Lessons Learned

- The use of CIALs to produce and disseminate high quality seed of improved bean cultivars provided important insights on what seed production systems work at the community level. CIALs are community organizations with an average of eight to 12 farmers who have prior experience conducting field experiments to validate and adopt new technologies and to produce seed of preferred, well adapted cultivars for local demand. By making use of these local organizations, more than 30 CIALs were able to participate in the production and dissemination of high quality seed of improved bean cultivars, thereby minimizing transportation costs and allowing the seed to be produced—and sold—at affordable prices.
- By using traditional commercial transactions, such as credit to be repaid in grain (two to three times the amount of seed acquired), labor, or other products, this locally produced, high quality seed was made available to farmers in the participating and neighboring communities. Additionally, improved seed was available when needed for planting, creating supply–demand conditions favorable for continuing seed production and dissemination of improved bean cultivars after the end of the project. So successful was this seed production system for local farmers that CIAL-produced seed grown with support from this project was never sufficient to fulfill customer demand, especially after farmers and their neighbors realized the yield benefits of using affordable high quality bean seed of improved varieties. This organizational design not only made use of local labor, but also helped ensure wide distribution of the improved seed because the CIALs that produced it have credibility among the local farmers.

Nicaragua

The Nicaragua program has been the most ambitious among the four countries, establishing a total of 223 functional CSBs in its five bean-producing regions, as shown in Table 2. By providing a start-up kit of inputs to plant one manzana (0.7 ha), the goal established by INTA was to multiply and to produce at least 15 cwt of seed per individual CSB— enough seed to provide 20-pound bags of quality declared seed to at least 50 smallholder farmers in a community (after seed conditioning, 15 cwt usually yields five to 10 percent less seed). The goal of the project for was to reach 10,000 farmers in Year 1, requiring the production of approximately 3,000 cwt (at a rate of 100lbs/ha this amount of seed produced is enough for 3,000ha of area planted). In preparation for potential failures due to climatic conditions or organizational factors, INTA projected that at least 75 percent of the overall goals would likely be achieved.

² *Apta* or *Quality declared* seed has been produced under certified seed protocols, but is not certified by the national entities in charge. The cost of certification has to be covered by the grower which means additional seed production costs, that can make certification impossible for smallholder farmers.

Table 3. CSBs established in the different regions of INTA–Nicaragua

INTA Regional Offices	2011	2012	2013
North Pacific	40	40	44
South Pacific	40	40	40
North Central	40	40	45
South Central	40	40	50
Segovias	40	40	44
Total	200	200	223

Source: BTB Country Reports

The INTA model consisted of organizing 223 CSBs in key communities in strategic bean producing regions where technical staff identified progressive farmers concerned about seed security and interested in utilizing improved technologies to increase bean yield. As shown in Table 3, the goal was to establish 40 CSBs per region and to follow up with their development in every year. In year 3 there was an effort to increase the number of CSBs based on seed demand as expressed by each INTA region. CSBs vary in number of members, bylaws of the organization, and the geographic extension of their member base. Each CSB has an identified leader farmer, called a *promoter*, with whom INTA technical staff interacts. The promoter received regular training on seed production and handling. Since the bank is able to increase their capital (mainly registered seed and production inputs), each CSB committed to providing 20 lbs of the quality declared seed to 50 farmers in their community or neighboring communities. The recipient farmers committed to pay back the CSB with seed or quality grain to maintain a reserve of improved genetic material. The BTB Project considers this model the best community-based alternative for a sustainable seed system. In this model, the quality of seed produced is constantly assessed by end users, the cost of the seed is considerably lower compared to certified seed available in commercial agriculture depots, and the seed is available a short distance from where the farmers live. This model thus translates into an economic advantage in that labor and transportation costs are saved even when the expected success rate falls close to 50 percent of the expected production level, as shown in Table 4.

While this model was highly effective in multiplying seed locally, it was not 100 percent effective in reaching the expected numbers of beneficiaries. Many CSBs faced challenges in getting paid back by farmers who were given the seed on credit. Other CSBs expressed they could not find 50 trustworthy farmers in the community where they worked. Internally, there were CSBs where organizational, climatic, and financial shortages led to the seed bank's failure to reach the expected number of beneficiaries. The high number of CSBs that were able to achieve high levels of seed multiplication, however, substantiates the model's potential. To make this model self-sustainable, however, future efforts need to concentrate on expanding the number of farmers who can access CSB-multiplied seed or simply supporting CSBs to produce just enough for their own community members.

Table 4. Success rate of CSBs in reaching seed production goals

REGIONS	SEED PRODUCTION (MT)			TOTAL
	2011	2012	2013	
North Pacific	26	15	11	52
South Pacific	12	7	14	32
North Central	24	21	32	76
South Central	29	21	43	93
Segovias	25	22	29	75
Total	119	74	128	321
Goal	136	136	136	409
Success rate (%)	87	57	93.97	82.53

Source: BTB Country Reports

Lessons learned

As the BTB Project came to an end, INTA confirmed it would continue to support 15 BCS in each of the four regions where INTA has offices. INTA will also promote the BCS model despite the challenges of establishing it a self-sustainable system in the community. The lessons learned from establishing 223 CSBs in INTA were the following:

- Challenges for seed recovery were faced by BCS in Year 1 because some farmers simply would not pay back the seed they received on credit, despite continued insistence by CSB committee members. In Year 2, some of the BCS did not provide seed to farmers they did not trust or who did not have the ability to pay back a seed loan. INTA had to adjust its expected goals for all CSBs across the board because not all CSBs could reach 50 beneficiaries that they deemed trustworthy in subsequent years.
- The time between harvesting CSB seed and its delivery to farmers was very short, so many CSB leaders did not have sufficient time to prepare the seed and disseminate it to beneficiaries. In Year 1, INTA helped find beneficiaries in nearby communities, but the practice was judged as poor since the CSB then expected INTA to collect the seed payment. INTA personnel do not have the mandate, incentive, or the time for this role. Besides, being in a collector's position harms their relationship with different families. INTA did not know this was going to be an issue in Year 1, but after their negative experiences of trying to collect credit payments from seed loan defaulters, INTA did not provide this assistance to CSBs in Years 2 and 3.
- Adverse growing conditions in some areas in the North Pacific region taught INTA a tough lesson in recognizing unsuitable bean production areas, regardless of the high demand for bean products among poor populations. In such situations, INTA does not recommend establishing seed banks; instead, they help farmer organizations buy high quality seed from other CSBs to improve their chances of producing good crop yields year after year.

Haiti

Through the BTB Project, thousands of farmers were provided with a two-kg bag of improved bean varieties, mainly variety DPC-40 released in the Dominican Republic. The project tried to establish local seed multiplication in Year 1 but did not accomplish this due to challenges in finding trustworthy partners. An alternative model to source quality seed of improved varieties was found by linking with Legume Innovation Lab's long-term partners in the Dominican Republic. As a result, the Comité Agricola Unitario (CAU) became responsible for producing certified seed in Year 2 for dissemination in Haiti.

The highlights of the BTB Project in Haiti are as follows:

- Sixty-nine (69) MT of variety DPC-40 were produced in the Dominican Republic under the highest standards of quality;
- Seed was disseminated to farmers during six different seasons to respond to different planting times in different parts of the country, from the low valleys to the mountains;
- 484.85 kg of *Rhizobium* inoculum were distributed at the national level in 54 localities;
- Six grassroots organizations were supported with seed multiplication and seed storage capacity for the continued expansion of their seed dissemination activities in their community and region;
- One experimental greenhouse was rehabilitated at the Faculty of Agriculture and Veterinary Medicine at the National University of Haiti;
- Two laboratories were restored to promote *Rhizobium* inoculum multiplication, one at FAMV in Port-au-Prince and another at Zanmi Agrikol in Mirebalais;
- Twenty-six thousand six hundred forty (26,640) households were reached with two kg of seed and 29,800 technical information sheets disseminated through different partners;
- Field days in Mirebalais were conducted at the Centre de formation de Fritz Lafontant(CFFL) school with participation of 23 students and 39 farmers coming to learn agricultural techniques from several areas in the department;
- Five technology dissemination plots were established with DPC-40 in association with several types of *Rhizobium*;
- Fifteen thousand (15,000) of the project's beneficiary families were informed of the new bean and *Rhizobium* technologies;
- Eight technicians and farmers from partner institutions, the National Seed Service (NSS), and IICA participated in an exchange visit to the Dominican Republic. At the end of the project, three of the institutions that BTB supported technically and financially in local seed production reported their best results, as compared to past results. Anecdotal information from farmers describes significant achievements, such as:
 - Gains in productivity up to 0.9 MT /ha, which is highly significant when compared to the national average of 0.25 MT/ha.
 - Quality seed is now available in Gonaives, Mirebalais, and Grand Goave because of the community-based organizations that now have access to irrigation and storage and are connected to SNS and UPR to access basic seed of improved varieties.
- Four silos with a capacity of 6.5 MT/unit were purchased for seed storage in Mirebalais and Gonaives;
- Twenty-two and a half (22.5) MT of DPC-40 was produced locally in March 2014 on 25 hectares (0.9TM/ha) under the supervision and with the assistance of IICA, SNS, and UPR.

- Five national technicians are now familiar with the technology used in the Dominican Republic and will replicate it at Hands Together and Zanmi Agrikol in subsequent seed production cycles.

Lessons learned

- The most important lessons learned in Haiti were how unaligned the interests of the private sector and the bean seed system can be in this country. Originally, the dissemination strategy was to involve private sector representatives who have presence throughout Haiti—in the form of agriculture boutiques—to combine strengths between pro-profit and development institutions. This original strategy could not have been more frustrating; matching business interests against development goals made partnerships with the private sector quite difficult.
- When it comes to reaching thousands of farmers in remote areas, it has been important to realize the cost of doing business in poverty-ridden Haiti. Distances from one community to another, best measured in difficult roads, took significant time to travel. After difficult vehicle travel, human resources and seed required additional travel hours on foot to reach beneficiaries. Such challenges convinced us that community-based seed multiplication approaches to achieve sustainability were the best option for realizing project objectives and goals.
- The variety DPC-40 showed potential for rapid adaptation in the low plains and in the mountains; however, DPC-40 has no resistance to drought, which is a serious problem in most parts of Haiti. More efforts to bring varieties with this characteristic would be welcome.
- The dissemination of improved seed cannot be done without systematic and/or continuous monitoring; in Haiti BTD funding only provided for seed and dissemination logistics; further investment is required to ensure the availability of improved seed for future planting seasons.
- To reduce losses due to inefficient postharvest storage techniques, unexpected rain, or lack of laborers during the rice harvest in regions like the Artibonite, mechanized threshing is strongly needed by organizations planting 10 ha or more for seed production;
- The *Rhizobium* strains CIAT 899 and CIAT 632 are well adapted to the diversity of existing agroecological areas in Haiti.

BTD's Contribution to NARS Institutional Strengthening

One of the major contributions to the institutional strengthening of the NARS has been the opportunity for them to be present in rural areas with high quality seed that started from Foundation Seed. For many years, NARS has lacked the capacity to secure this access, which affected the possibility of responding to certified or apta seed demands. The Bean Program at Zamorano was able to increase the production of foundation seed of more than 15 improved bean varieties required by project collaborators from Honduras (DICTA and NGOs), Nicaragua (INTA), Guatemala (ICTA), and Haiti (NSS and NGOs). This renewed the NARS's reputation as a good source of this category of seed for other projects. Additional requests for foundation seed came from other regional projects, including FAO Seed for Development projects from Honduras and El Salvador, the national research institutions from Costa Rica and El Salvador, the FTF TechnoServe Project of Honduras, other NGOs from Honduras, and private companies from Guatemala.

In the last 30 years, several efforts have been made to produce high quality seed at the community level to satisfy a portion of the local demand for affordable seed. This artisan seed production approach failed after many attempts by governmental and private organizations supported by international donors. The basic problem with this model is that the value chain approach (breeder-, foundation-, registered-,

certified) necessary to produce high quality seed by farmers was not included or was inadequately implemented in the artisan seed model.

Impact on Gender

Ensuring gender equity in the selection of technologies for dissemination and ensuring that women have access to the technologies disseminated was a priority of the BTD Project. In particular, consideration was given to red and black bean types that are not only highly productive (thus maximizing the return on the investment of a women's time to produce food), but also require less additional inputs for crop management. For instance, disease resistance in improved varieties reduces the need for farmers (which include women) to purchase and apply costly and potentially harmful (to the environment as well as animal and human health) fungicides, bactericides, and insecticides to control vectors of plant viruses. The use of *Rhizobium* inoculants also benefitted women because it reduced the need to purchase synthetic and costly nitrogen fertilizers. The project intended for more than 10 percent of its beneficiaries to be women; this goal was surpassed more than twofold.

The project's partners reported active participation by women in training events and the organization of CSBs. Data from Nicaragua shows that at least 21 percent of CSB participants were women; in the demographic profile of project beneficiaries, in Guatemala, 58 percent of participants in the highlands were women while 27 percent in the rest of the country. In Honduras, 25 percent of CIAL members were women; and in some instances, CIALs were formed exclusively of women. In Honduras, priority was given to women's participation in the production, conditioning, and packaging of seeds such that 50 percent of the laborers for these activities were women. In Haiti, specific rates of women participation indicate that more than 25 percent of direct seed recipients were women.

Farmer Perceptions of BTD Project and Seed Dissemination Activities in Guatemala, Honduras and Nicaragua

As part of the monitoring and evaluation (M&E) component of the BTD project, Reyes, DeYoung, and Maredia (2014)³ implemented beneficiary household surveys in Guatemala (2013), Honduras (2013) and Nicaragua (2012) to learn about BTD beneficiary farmers' profiles, their bean production economy, and their perceptions (positive and negative) of the availability of bean seeds distributed by the project. Because of the limited progress in project activities in Year 1 and the difficulty associated with training and mobilizing enumerators in Haiti, a household survey was not implemented in this country. The survey data are representative of the first year (Nicaragua) and second year (Guatemala and Honduras) of the project. These authors first evaluated the key characteristics of the beneficiary households, including size of landholding, ownership of household, and productive assets, among other profile characteristics. They

3 Byron Reyes,3 David DeYoung and Mywish Maredia. 2014. Effectiveness of the bean seed dissemination models implemented under the Bean Technology Dissemination (BTD) Project: Results of key informant interviews in Guatemala, Honduras and Nicaragua Draft report to the Bean Technology Dissemination Project. Legume Innovation Lab, Michigan State University.

then asked beneficiary farmers about their perception on the BTD project seed dissemination and seed system development efforts. While they found that beneficiary households were generally poorer in Guatemala than in Honduras and Nicaragua, in all three countries the beneficiaries reported beans being within the top two most important crops in total area planted, purchased inputs devoted, and family labor invested.

Key findings:

- 1) Most farmers stated that the new varieties had good yields and that they would continue to plant the same or more of that variety in future seasons.
- 2) Particularly in Honduras, most farmers reported receiving seeds in sealed, labeled bags, which is important to create differentiation between seeds and grain. Further, most farmers reported that the quality of the seed they received was higher than or similar to other seed they planted. This is thought to be essential in cost recovery and payments for the seed.
- 3) Key factors influencing use of the quality seeds were accessibility and timeliness of seed delivery, yet performance varied on these two factors. Almost 80 percent of farmers in Honduras received the seeds in the community where they reside, while only 62 percent in Nicaragua and 56 percent in Guatemala reported the same. The timeliness of delivery also varied, with many farmers reporting issues with late seed deliveries, especially in Guatemala where 50 percent of recipients reported this issue. In contrast, only one out of five farmers reported late deliveries in Nicaragua and a similar share reported the same in Honduras. These two factors (the where and when) are closely linked; thus, it is not surprising that in Guatemala, where a higher share of farmers had to travel outside the community to obtain seed, issues with late deliveries were more common.
- 4) Cost recover was not a driving force in the original design of the project and, thus, it is not surprising that for the first and second years, “more than 70 percent of farmers in Guatemala and close to 50 percent of farmers in Honduras reported receiving the project seed free of cost. Against this, only 5 percent farmers in Nicaragua received seed “free of cost.”
- 5) While the majority of farmers reported that the amount of seed they received was adequate to meet their needs, an important share of farmers indicated the desire for more seed (44 percent in Nicaragua for example).
- 6) Willingness to pay for seed moderated the desire for larger quantities. Among the farmers desiring to buy more seed, farmers were willing to pay a 36 percent , 85 percent, and 27 percent price premium above the average grain price received by farmers in Guatemala, Honduras and Nicaragua, respectively. Not all farmers, however, expressed a willingness to pay to obtain more seed.

Key Informant Interviews with Respect to the Effectiveness of the Bean Dissemination Models Implemented under the BTD Project

A second M&E activity carried out by Reyes, DeYoung, and Maredia⁴ consisted of an in-depth analysis of the unique features of different models for seed multiplication and distribution implemented by the BTD project. The goal of this activity was to identify principles of sustainability both present and/or absent from these different models and then derive implications and lessons for broader applicability to other countries where Innovation Lab research programs are active. For the same reasons described in previous sections, this activity was conducted only in Guatemala, Honduras, and Nicaragua. A total of 25 interviews were conducted in Guatemala and 36 interviews in Honduras. In Nicaragua, two survey instruments were developed to collect data on the CSBs established in the first two years of the project. About 200 CSBs were included in the survey, but only 153 responses were obtained for the first survey (about the CSB's characteristics) and 149 responses for the second (about seed production costs).

Key findings:

- 1) Seed production was under the responsibility of different partners, depending on the type of seed. While production of Foundation and Registered seed was under the responsibility of governmental agencies and Zamorano (in Honduras), production of quality declared seed was under the responsibility of many partners, including government agencies, CIALs, farmer groups, NGOs, CSBs, etc. Seed dissemination was done in all three countries through a network of collaborators that included NGOs, CSBs, CIALs, and governmental offices, among others.
- 2) The BTD project was designed with the aim of making production and distribution of quality declared seed sustainable over time. To reduce farmers' dependency on receiving or expecting free seed from the project, beneficiary farmers were told they needed to pay back the seed they received. In general, the price of the quality declared seed (determined by the amount of grain farmers needed to return compared to the amount of seed they received) in all three countries was the same or twice the price of grain.
- 3) While most beneficiary farmers agreed to the payment agreements, repayment rates were variable. In Guatemala, key informants reported that roughly only one out of every three farmers paid back the agreed amount of grain for the seed they received in 2012. In contrast, in Honduras, between 57 percent and 71 percent of beneficiary farmers receiving conventionally bred varieties and 82 percent of beneficiary farmers receiving participatory bred varieties have paid back the agreed amount of grain for the seed they received. In both Guatemala and Honduras, the agreed amount varied. However, in Nicaragua, 53 percent of beneficiary farmers repaid twice the amount of seed they were given, which is a low-bound estimate since it excludes farmers who may have paid different amounts (e.g., lb. x lb.) This variability in payment rates is understandable because enforcing payment agreements is difficult. As one might expect, low payment rates could threaten the sustainability of these models.

⁴Mywish K. Maredia, Byron Reyes and David DeYoung, 2014. Farmer perspective on the use of and demand for seeds of improved bean varieties: Results of beneficiary surveys in Guatemala, Honduras and Nicaragua. Draft report to the Bean Technology Dissemination Project. Legume Innovation Lab. Michigan State University.

- 4) Farmers in all three countries were satisfied with the varieties and quality of the seed they received . However, although most informants in Guatemala and many in Honduras reported that the amount of seed distributed per farmer in 2012 was adequate, in Nicaragua, CSBs could not satisfy the demand for seed, suggesting that farmers wanted more. Further, while most seed was distributed on time for planting, there were some small issues with late seed deliveries across all three countries, but most farmers in all three countries received the seed on time.
- 5) Across countries, there were many strengths and weaknesses of the models implemented by the BTD project to distribute seed to beneficiary farmers. Some of the common strengths across countries were the installed capacities of partners and the high quality of the seed produced and distributed . Some common weaknesses included the limited training of partners, limited technical assistance to farmers, and, in a few cases, late seed deliveries.
- 6) To make these models more efficient in the future, key informants in Guatemala and Honduras reported constraints in both the supply (e.g., additional resources, producing more seed/varieties) and demand (e.g., finding new markets) sides of the seed value chain that should be considered. Also, it is clear that partnering with other institutions or strengthening alliances with partners is necessary to become more efficient and reach as many farmers as possible.

These results suggest that to make these projects more successful, it is important to select the right partners along the supply chain for better coordination to achieve the quality, volume, and timing desired by seed end users. Since late seed deliveries were more common in models without local seed production (i.e., within the community), finding ways to produce the seed closer to where beneficiary farmers will receive it should help avoid late seed deliveries (though cost implications should also be considered).

Lessons Learned

As the BTD Project came to a close, it was evident that the most significant contributions to sustainable seed systems were accomplished in Nicaragua, thanks to the community-based seed multiplication model known as Community Seed Banks (CSBs). An early partnership with INTA helped establish CSBs for the multiplication of quality seed of improved varieties as a strategy to meet the needs of smallholder, resource-poor farmers. While INTA had the idea, the BTD Project supported the effort. This supportive technology provided the emerging base to extend the model to Guatemala and Honduras during Years 2 and 3, where important lessons were learned in establishing similar seed multiplication and dissemination models. In Haiti, where project execution conditions were more difficult, it was not until the last season of seed multiplication that the community-based seed multiplication and dissemination model was tried in two different locations. This experience is discussed ahead in more detail.

The experience of this project in promoting the CSB model provides strong evidence to claim that the model is adaptable to a variety of rural conditions, but there needs to be more investment in understanding how to accommodate variations in community organization, types of bean-based cropping systems, and socioeconomic environments. The BTD Project has also established that the CSB model is transferable to other countries in Central America (e.g., Honduras and Guatemala). Even when the model presents significant challenges for sustainability, it has nonetheless proven to be the best alternative to addressing the costs, logistics, and organizational problems impacting bean seed systems. The Legume Innovation Lab is convinced that more resources need to be spent to understand how the CSB model can be adapted to different environments where more and different lessons can be learned. Already, the Legume

Innovation Lab is making significant investments with the U.S. Department of Agriculture in Honduras to establish 100 new CSBs; in the next three years, at least 500 CSB-like organizations will be organized in the Guatemalan highlands in collaboration with the USAID Mission to Guatemala. The CSB has proven effective in bringing affordable, high quality seed of improved varieties to remote, rural communities in the region; these lessons should be applicable to other continents.

While implementing seed systems involving multiple actors presented some challenges for Guatemala, Honduras, and Nicaragua, the nature of the problems faced in these three countries were different than those found in Haiti. In post-earthquake Haiti, public sector representatives were immersed in reconstruction and recovery efforts and had limited ability to participate in our project and the opportunities it presented. In response, the MO reverted to a simpler seed dissemination model with the assistance of IICA, which was effective in reaching thousands of farmers in rural areas through a network of NGOs but did not have the field presence or financial resources to play the role of a local NARS (as in Guatemala, Honduras, and Nicaragua) to support and follow through with community-based seed multiplication efforts. Thus, in Haiti, the BTM Project succeeded in disseminating quality seed that resulted in increased crop yields, which provided clear evidence that such disseminations can positively impact widespread hunger and malnutrition. The evidence that such access to quality seed can sustain these results into the future has been recorded in Honduras, Guatemala, and Nicaragua. Expanding this success to Haiti is a reasonable future goal.

Although a sustainable seed system was not established in Haiti, the BTM Project recognized that an alternative program could be developed there with related long-term positive impacts. BTM partnered with the University of Puerto Rico to produce *Rhizobium* inoculants for common bean in Haiti and to provide technical guidance with the development of protocols to evaluate response to inoculation with elite strains. Biological Nitrogen Fixation through *Rhizobium* inoculants has been around for decades with strong indications of success at a very low cost compared to only using chemical fertilizers. As a result, the BTM Project built capacity for inoculant production into and established a network with growers in Haiti.

By continuously monitoring and analyzing their technology research, BTM expanded its effects in each of its participant countries significantly and appropriately to environmental circumstances, ensuring that long-term gain from BTM's work would continue to be realized after the project's completion. The following lessons learned summarize the learning process the MO and partners went through in this experience to achieve sustainable seed systems in future technology dissemination opportunities.

Building on the Experience of Lead Farmers

Two different approaches were implemented for seed production and dissemination in Honduras. DICTA, the government research and technology transfer institute, worked with two groups of farmers: individual seed producers who have the field facilities and crop management experience to produce good quality seed and a small group of farmers organized as seed community banks. Both types of seed producers received training and technical assistance on seed production and conditioning from DICTA. Technical support was provided from researchers and technical personnel from the central office of DICTA at Tegucigalpa and from extension personnel located at regional offices.

The Weight of Logistics Cost in Bean Seed Production

Based on previous experience, Zamorano preferred to work in collaboration with partner NGOs (PRR, FIPAH) and small farmer groups organized in CIALs due to the low cost per MT of working locally. CIALs are community organizations with an average of 8–12 farmers with prior experience conducting field experiments to validate and adopt new technologies. With this experience, they have learned where to save on production costs and how to distribute the labor among members. Their knowledge of well adapted cultivars for local demand provides the confidence that, except for unforeseen weather events, the group will be successful in producing apta seed at low cost. Using this approach, more than 30 CIALs were able to participate in the production and dissemination of high quality seed of improved bean cultivars with a high rate of farmer satisfaction and cost recovery. Most importantly, by using local labor and minimizing transportation costs, the CIALs were able to produce and sell high quality seed at affordable prices.

Use of Traditional Commercial Trade-In when Marketing Community-Produced Seed

Seed producing organizations in Honduras relied on payment arrangements such as seed credit to be repaid in grain (two to three times the amount of seed acquired) or an exchange for labor or other products (such as maize, sugar, salt, etc.) Such flexibility in payment provided farmers with the ability to access seed when they needed it, even if they did not have cash at planting time. The locally produced, high quality seed became available to farmers in the participating and neighboring communities who were also cash-strapped but willing to access the seed on credit terms. The key was providing the seed when farmers needed it. Because the community-based group had a reputation for high quality production, the system created supply–demand conditions favorable for continuing seed production and dissemination of improved bean cultivars after the formal project ended. Significantly, the seed produced by CIALs with support from this project was never sufficient to fulfill the demand of customers, especially after farmers and their neighbors realized the benefits of using affordable high quality bean seed of improved varieties. The demand outpaced the supply, assuring the producers that their seed would sell in the future, which helped assure their willingness to continue producing high quality seed.

Price affordability and cost recovery challenges

The results obtained by Reyes, et al., suggest that if this and similar projects are to be sustainable, it is important to supply quality declared seed at an affordable price (which was possible under the BTB project). Second, seed multipliers and distributors (such as CSBs and CIALs) have to determine the best way to recover the cost of producing the quality declared seed even when there is no secured market. The data show that this is not easily done because it is challenging to enforce payment arrangements among community members unless the quality declared seed is only sold by a cash transaction at the time of delivery. If beneficiary farmers do not pay back the seed they receive on credit, it will be difficult for the seed multipliers to have enough capital to continue producing seed over time. The results suggest that models that includes local partners within the community to produce and distribute the seed might have a better chance of recovering these investments than models where seed is brought from outside at a higher cost.

How to Use the BTD Experience in Future, Similar Initiatives

The BTD Project has placed priority on implementing activities that contribute to the establishment of “sustainable” bean multiplication and dissemination systems in each country. This sustainability goal has also been given nearly equal priority as the dissemination targets (number of beneficiary farmers) by the NARSs partnering in the project. The consensus of the bean sector based on years of experience in both developed and developing countries is that community preoccupation for and commitment to ensuring “seed security” plus farmer ownership of the production of high quality seed (of large-seeded self-pollinated staple grains such as beans) to meet local planting needs are critical “sustainability factors” that should be considered in the design of any bean technology dissemination project. In this regard, the BTD Project’s foremost legacy for future similar initiatives in bean seed systems is represented by the attention to promoting the establishment of Community Seed Banks (CSBs) in partnership with INTA in Nicaragua and in Honduras with DICTA and EAP–Zamorano, in Guatemala with ICTA. INTA’s vision has been to implement a sustainable community-based approach for the multiplication of quality seed of improved varieties of staple grains.

CSBs are not a panacea as many weaknesses affect community organizations that lead to failure in the mid and long term. However, keeping in mind that aspects of bean value chains constantly reveal the financial challenges of smallholder, CSBs are the best tools that can be outlined in terms of mechanisms to reach geographically dispersed, resource-poor farmers. Community Seed Banks represent a model by which small groups of farmers with social linkages collectively take measures to assure their own “seed security”. Through the multiplication and effective storage of seed, farmers in a community are assured of having access to affordable quality seed to plant their next crop, even if they have experienced a crop failure due to whatever reason. As resource-poor smallholder farmers clearly understand, seed security directly translates to both household food security and the opportunities to generate needed income.

The BTD experience has been highly positive for the Legume Innovation Lab. Reyes et al., (2014) assessment of the Community Seed Bank model has accounted for this model’s strengths and weaknesses with key insights when transferring the model to countries where socioeconomic-political contexts requires flexibility and adaptation. Each country is distinct due to differences in national seed policies, roles of government entities in the production of foundation and “registered” seed stocks and the certification of “seed” production, government agriculture development priorities, and the existence of functional extension programs required to provide technical assistance to rural farm communities. Clearly one rigid model cannot be forced upon communities of farmers in other contexts (i.e., Sub-Saharan African countries). One must have insights into community social structures and decision making, plus understand the keys to success of alternative approaches that might facilitate smallholder farmer access to and adoption of yield-enhancing technologies such as seed of improved varieties within that context.

Project experience in Guatemala during the three-and-a-half years revealed that the NARS in all countries, even Haiti, considered the CSB model to be compatible with their mission of ensuring national seed and food security. Constraints encountered however included the capacities of NARS to afford its implementation, follow up and supervision this model demands despite its modest cost per CSB (circa \$600 with some modifications). This modest cost however requires a commitment of cost share by partner institutions, but that can be provided by donor programs that consider legumes a priority crop in achieving food and nutrition security of rural populations.