Report of the Central American/Caribbean Regional Bean Research Workshop

25-27 July 2017 – Tegucigalpa, Honduras

The principal objective of the meeting was to meet with bean researchers from Central America and the Caribbean (Table 1) to discuss recent achievements and to discuss future research and training needs to promote bean production and consumption in the CA/C region.

Table 1. List of Participants in the CA/C Regional Bean Research Workshop.

Name	Institution / Country	email
Juan Carlos Rosas	Zamorano / Honduras	jcrosas@zamorano.edu
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James Beaver	University of Puerto Rico	james.beaver@upr.edu

During the first day of the workshop, participants from each country provided an overview of the bean sector and described recent research achievements. One could appreciate from the presentations that there is a wide range of cropping systems and scales of production within the region. Black and small red beans are produced throughout Central America and the Caribbean. A significant amount of beans crosses borders in Central America and Mexico. This should contribute to more stable prices for producers and should provide greater food security.

Emigdio Rodríguez, leader of the IDIAP bean research program in Panama, has breeding beans for contrasting zones of extreme poverty and high productivity, biofortification (iron content in the seed) and drought tolerance as major breeding objectives. High productivity zones use inputs. Andean beans respond to fertilization but there is a need to control costs. Indigenous and poor farmers use low levels of inputs and often have acid and low P soils. NUA 27 and NUA 24 produced mean yields >1,700 kg/ha and had iron content in the seed >75 ppm when evaluated over three locations. These lines are expected to be released in different regions of Panama. Web blight is a serious constraint for beans produced in the region of high productivity. Minimum tillage is a common practice to reduce soil erosion and the spread of the web blight pathogen from soil splashing during periods of intense rainfall. Glyphosate is commonly used to eliminate weeds before planting. Emigdio noted that this practice has become more problematic due to changes in weed populations that are more resistant to this herbicide. NUA 336 had the lowest level of web blight infection in trials conducted in Panama. The IDIAP bean research program develops some of its own breeding populations. Other populations come from CIAT and Zamorano.. Participatory plant breeding techniques are used to evaluate bean lines. Light red kidney lines P-09-11 and P-13-38 were selected as candidates. Future breeding objectives will add heat tolerance and resistance to angular leaf spot. Rigid seed certification rules and regulations serve as an impediment to the use of alternate seed production schemes. This constraint was mentioned by other national bean research programs. Emigdio expressed interest in participating in a CA/C regional bean research network. He offered to screen bean lines for reaction to web blight and has funds from IDIAF to participate in workshops and annual meetings of a regional project. He has a candidate and financing available for M.S. degree training in plant breeding. Many of the national bean research programs indicated a need for training in conventional plant breeding. These conventional plant breeders should have a strong multi-disciplinary training because responsibilities in a CA/C bean research program will likely cover a wide range of activities. Weed science, management of soil fertility and expertise in the effects of climate variability are other areas of knowledge that would benefit the bean research program in Panama.

Juan Carlos Hernández, leader of the INTA bean research program, made a presentation describing bean research achievements in Costa Rica. Larger scale producers are in northern Costa Rica near the border with Nicaragua whereas most of the bean producers in the southern Brunca region are small-scale farmers who continue to use landrace varieties although some improved cultivars such as 'Cabecar' are used. Recent variety releases include Tayníí which is a breeding line from Zamorano. Web blight was identified as a serious biotic constraint. Lines such as MHN 322-49 and other material from Zamorano and Puerto Rico were among the most

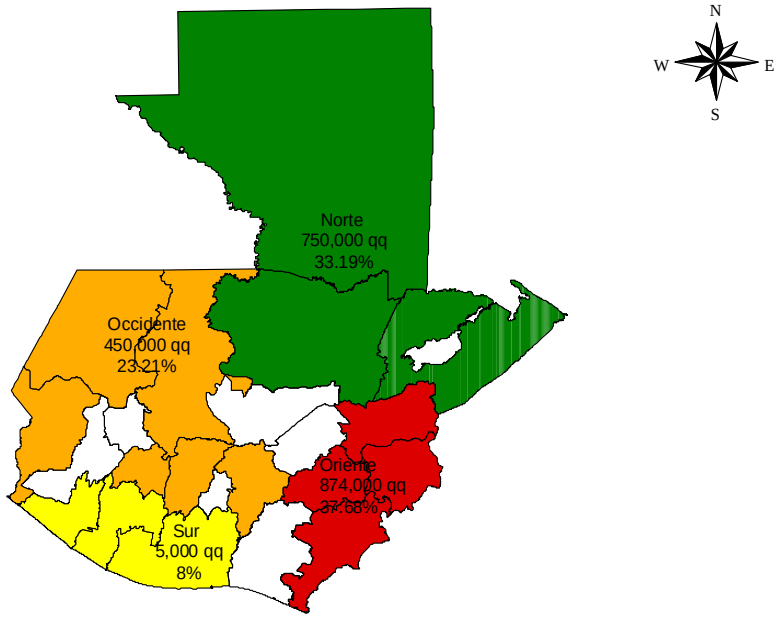
resistant to this disease in trials conducted in Costa Rica. Several lines such as ALS 0532-6 (small red) and ALS 0546-60 (black) from Zamorano have high levels of resistance to angular leaf spot. Juan Carlos described a niche market for yellow (mantequilla) beans in Costa Rica. BGYMV and BCMV resistant yellow bean breeding lines from the UPR have been used to develop yellow bean breeding lines. SJC 730-79 performed well in low P soils. SEF 15 and Tep 22 had the best performance in terminal drought trials. Tep 22, SEN 52 and SJC 730-79 were the highest yielding lines under high temperatures in Quepos, Costa Rica. Farmers in Costa Rica are utilizing a BGYMV and BCMV snap bean line from the UPR. Farmers in Costa Rica prefer snap beans with shorter (15 cm) pods compared with consumer preference in the U.S. Juan Carlos believes that there are niche markets for beans (gourmet, low C footprint and biofortified varieties) in Costa Rica. There is also some interest in tepary and Lima bean (determinate, with opaque black seed). Major constraints for common bean production include angular leaf spot, high temperature, low soil fertility, drought, leafhoppers and charcoal rot. The University of Costa Rica produces foundation seed stock which is provided to both the official seed certification program and farmer associations involved in the production of quality declared seed. Additional informal training in protocols for seed production, the identification of seed-transmitted diseases and post-harvest management of seed would contribute to more sustainable seed production. Juan Carlos proposed more regional research with post-harvest problems such as cooking time, discoloration of seed and bruchids. Gaps in knowledge include weed management, soil fertility and studies of the adoption and impact of variety releases.

Mantequilla bean seed in Costa Rica – source J.C. Hernandez

Aldemaro Clará, leader of the CENTA bean research program, described achievements in El Salvador. Major constraints include BGYMV, angular leaf spot, web blight, common bacterial blight, bean pod weevil, bruchids, drought, low soil fertility and acid soils. The black bean BRT 943-20 from Zamorano is a candidate for release. CENTA EAC (SJC 730-79) a heat tolerant

small red cultivar that is widely adopted in El Salvador. In 2015, 42,000 of 137,436 total bean producers in El Salvador planted this cultivar. At present, CENTA does not generate bean breeding populations although it has the capacity to evolve into a mature breeding program. Juan Carlos Rosas volunteered to evaluate with molecular markers lines from El Salvador and other CA/C bean breeding programs that are candidates for release. This would allow CA/C bean programs to have a better idea of the combination of genes that contribute to local adaptation. It might be useful to conduct a genetic study to compare landrace varieties and recently released cultivars in CA/C to determine what genomic regions have changed from selection. (e.g. Fang et al. 2017. Genomic analyses in cotton identify signatures of selection and loci associated with fiber quality and yield traits. Nature Genetics 49:1089-1098). Aldemaro proposed using participatory plant breeding techniques in regions where the diffusion of seed has been more difficult. Seed banks and local seed production would contribute to more sustainable seed schemes. Gaps in expertise include plant pathology, entomology, agricultural economics and seed systems.

Angela Miranda, leader of the ICTA bean research program, described achievements in Guatemala. Most of the increase in bean production in Guatemala has been related to an increase in area of production. Future increases in bean production should come from greater productivity. The Petén Department produces double the bean production in Jutiapa, the second ranking department in Guatemala. Therefore, there is an urgent need for ICTA bean research program to have a greater presence in Petén. The research program plans to focus on the release of varieties to increase yield and reduce production costs and environmental contamination. No more than 15% of the bean crop in Guatemala is produced in monoculture, thus bean cultivars need to be adapted to intercropping. Constraints in the lowlands (BGYMV, BCMNV, web blight, angular leaf spot, common blight, bean pod weevil, drought, high temperature and low soil fertility) differ from the highlands (anthracnose, ascochyta, rust, angular leaf spot, bean pod weevil, low soil fertility and frost). The ICTA bean research program will soon have the most complete team of investigators in CA/C. During the past five years, they have studied the virulence patterns of the most important bean pathogens. New breeding objectives include resistance to bruchids, leafhoppers and charcoal rot. The program plans to identify native *Rhizobium* strains from different regions of Guatemala. The ICTA bean research program will soon have the capacity to routinely conduct marker-assisted selection for traits of economic importance. Advanced breeding lines with Co-4^2 gene for anthracnose resistance was selected with molecular markers. A total of 1093 $F_{2:3}$ lines were selected from crosses with sources of resistance to bruchids. Gaps in expertise include plant pathology, entomology, plant physiology, seed production and agricultural economics. A BGYMV resistant and high-yielding black bean breeding line will be released as 'ICTA Patriarca' (MHN 322-49//ICTA Ligero/XRAV 40-4). The web blight resistant line 'ICTAZAM ML' (ICTA Ligero/MHN 2-2) is also under consideration for release for the lowlands of Guatemala. During the past year, a climbing bean line was released in the highlands as 'ICTA Utatlán'. A 'bolonillo' line was released as 'ICTA Labor Ovalle'. Earlier maturity in the highlands helps to avoid damage caused by bean pod borer.



Bean production zones in Guatemala – source Angela Miranda

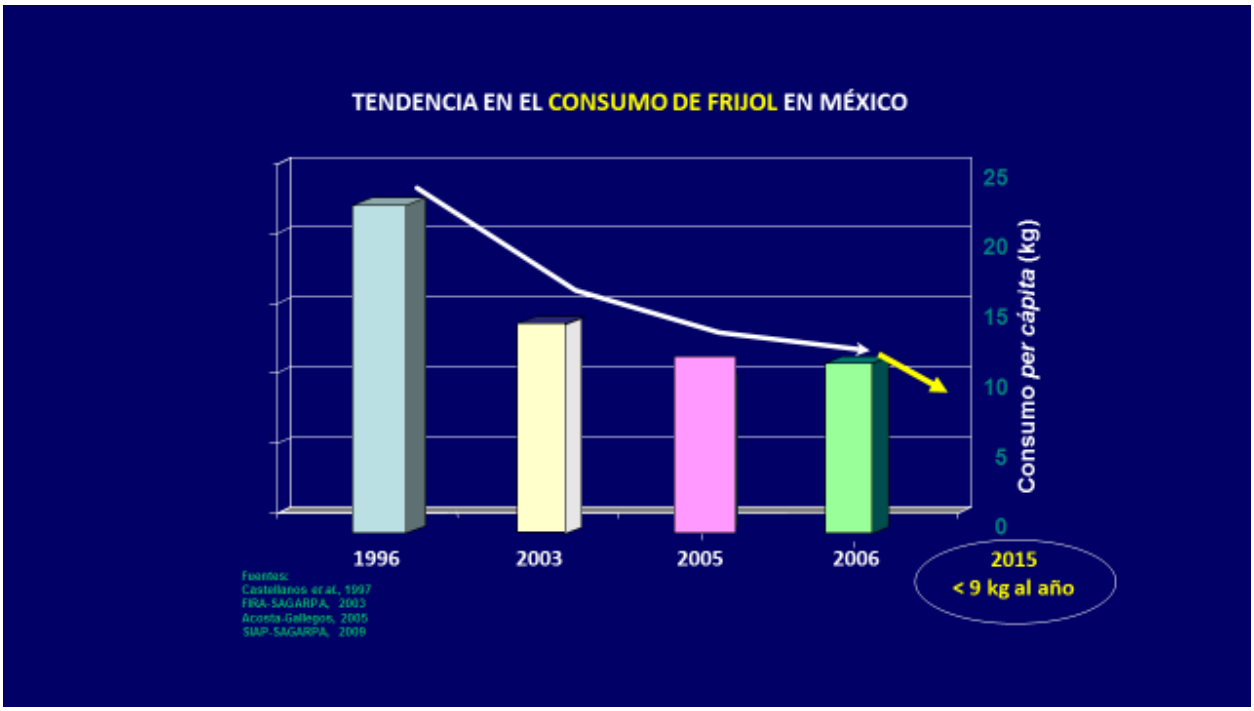
Danilo Escoto, leader of the DICTA bean research program, provided an overview of achievements in Honduras. He described the recent release of the small red bean 'Paraisito Mejorado II' [Carrizalito *2/Paraisito Criollo (IBC-302-29)]. This line has excellent seed type and resistance to BGYMV and BCMV. Researchers at the UPR found this line to have superior biological nitrogen fixation characteristics. Other recent releases include 'Honduras Nutritivo', the black beans 'Azabache 40' (same line as Sankara) and Lenca Precoz´.´All these varieties were developed in collaboration with the Zamorano Bean Research Program with support from the Legume Innovation Lab project. Breeding objectives include earlier maturity, tolerance to drought and high temperature, improved nutritional quality, adaptation to low soil fertility and resistance to major diseases and pests. New research objectives include resistance or management of thrip and mite populations in some regions of Honduras. Research concerning the use and management of fertilizers (domains of recommendation needed for fertilizer use and adaptation of varieties). How much could be gained by selecting for adaptation to specific environments? Formal seed regulations are inflexible and complex which impedes the release of bean varieties for niche environments (a limiting factor noted in El Salvador, Honduras and Mexico). Danilo observed that climate change is affecting planting dates and zones of production. Research need to anticipate these changes. Participatory plant breeding techniques can be used to help validate the performance of bean lines and identify potential niche markets for beans. Danilo noted that the use of subsidies for inputs in Honduras has help to promote the dissemination and adoption of new bean cultivars. Rotation of sugarcane and beans is

becoming more common in certain regions of Honduras. Gaps in expertise include socio-economics, entomology, seed technology and crop management (agronomy).

Juan Carlos Rosas described a few of the achievements of the bean research program at Zamorano including the development and release of bean cultivars with greater tolerance to drought, low soil fertility and heat. The regional bean research network in CA/C has a record of success in collaboration since the 1980s. The use of recurrent selection has proven to be successful for quantitatively inherited traits such as biological nitrogen fixation and resistance to web blight. Recurrent selection is possible with long-term support from donors such as the Legume Innovation Lab. The development of a differential set of lines for nodulation will help to evaluate the effectiveness of native strains of *Rhizobium* spp. Black bean lines MHN 322-49 and Lenca Precoz (MEN 2201-64 ML) have performed well under moderate levels of drought stress. Effective field techniques are used at Zamorano to screen for resistance to BGYMV and angular leaf spot. The UPR contributes by screening beans in the greenhouse for resistance to BCMNV and in the field for web blight resistance. The superior performance of tepary beans under drought and heat stress was discussed. Dr. Rosas made another presentation describing opportunities for continued bean research collaboration in CA/C. Products of the collaboration include the development and release of improved bean cultivars, formal and informal training of researchers and farmers in different disciplines and the development of new research techniques. Dr. Rosas noted that many of the CA/C bean research programs are mature which should allow a greater variety of research and possibly allow achievements to be made at a greater rate. National bean research programs can make greater contributions including the regional testing of bean lines. Collaboration and communication between CIAT and USAID-funded projects needs to be strengthened. There should be more emphasis in research and training in crop management, including sustainable seed systems, research to improve the productivity of the maize/bean cropping system, practices that improve soil productivity and water management systems for small-scale bean producers. Production of basic seed remains to be an important constraint.

Low soil fertility screening nurseries – Zamorano 2015

Dr. Francisco Ibarra, INIFAP bean breeder, described recent research achievements in southern Mexico. States such as Veracruz and Chiapas produce black beans under conditions like CA/C with many of the same constraints. The most recent black bean release 'Verdín' is well adapted to the lowland tropics. BGYMV, BCMNV, rust, anthracnose, web blight, charcoal rot, acid soils, high temperature and terminal drought are important constraints. The INIFAP bean research program has locations that are reliable for screening for specific biotic and abiotic traits. Participation of INIFAP in the CA/C regional network would increase the capacity to evaluate and select superior bean germplasm. Production of basic seed stocks in Mexico is a major limiting factor in some regions. Local production of seed with support from municipalities is used to increase seed supplies. Artisan seed production in Veracruz is successful (Quality Declared Seed) but mixtures occur after only a few years. In another presentation, Dr. Ibarra noted that per capita consumption of beans in Mexico has declined from >20 kg in 1996 to < 9 kg in 2015. This negative trend does not bode well for human nutrition and likely contributes to lower prices for the bean crop in Mexico. Large quantities of beans are imported. Local consumers like imported 'Michigan' beans because of their high quality. A sister line of 'Sankara' has been used by INIFAP bean breeders to develop black bean lines that combine resistance to BGYMV, BCMV and BCMNV. Earliness is considered an important trait to avoid terminal drought. Some of the UPR bean breeding lines may be useful as progenitors to introgress rust resistance. Gaps in knowledge include biotechnology, plant pathology, agricultural economics and plant physiology. Dr. Ibarra noted that there are groups in Mexico conducting basic research such as sequencing the common bean and *Rhizobium* genomes but the interaction with the INIFAP bean breeding program is limited.



Decrease in bean consumption in Mexico – source: Dr. Francisco Ibarra

Dr. Raphael Colbert, bean breeder and Quisqueya University professor, described recent achievements in bean research in Haiti. He presented a map that showed that much of the bean production (247,000 ha in total) is concentrated near the border with the Dominican Republic. Major constraints include BGYMV, BCMNV, powdery mildew, leafhoppers, whiteflies, bruchids, low soil fertility, salinity, high temperature and drought. He described recent bean variety releases by the National Seed Service with support from the Legume Innovation Laboratory. During the past few years, Dr. Colbert has evaluated the performance of bean lines at several different locations in Haiti and has identified several promising breeding lines. He has begun to develop breeding populations. Farmers need training in crop management practices such as the use of appropriate seeding rates for seed having higher quality and the management and use of fertilizer and pesticides. Gasner Demosthene was recently named to be the Director of the National Seed Service (NSS) in Haiti. Close collaboration between the NSS and the Quisqueya University project should improve the capacity to test, release and disseminate new bean cultivars in Haiti.

Bernardo Mateo, IDIAF bean breeder, described recent bean research achievements in the Dominican Republic. The recent release of the black bean cultivar 'Charlona Negra' has resistance to BGYMV, BCMV and the *Ur-5* gene for resistance for rust. It is also tolerant to high temperature and drought. Legume Innovation Lab project S01.A4 assisted IDIAF in screening the line using molecular markers linked with disease resistance genes. BGYMV, BCMNV, rust, drought are major constraints. Bernardo plans to continue to collaborate with the UPR to develop Andean and Middle American beans that combine resistance to disease and bruchids. Bean producers in the Dominican Republic played a major role in producing seed of the black

bean cultivar 'DPC-40' for Haiti. The Dominican Republic has the potential to be an important source of higher quality seed for bean producers in Haiti.

Dr. James Beaver made a presentation that provided an overview of research and training achievements of Legume Innovation Lab project S01.A4. The project has collaborated with CA/C bean research programs to develop, test and release of numerous common and tepary bean cultivars and breeding lines that have greater levels of resistance to disease and/or tolerance to abiotic stress. The project has identified new sources of disease resistance and tolerance to abiotic stress in common bean and tepary bean. The virulence patterns of several different pathogens have been characterized and molecular markers for several different traits are under development. Lines with bruchid resistance are ready to be tested on farms. Numerous graduate and undergraduate students have received training at the UPR and Zamorano. The project has supported five workshops. A web site is needed to share information from the CA/C network. Tim Porch's agreed to post information concerning this workshop (including presentations) on the USDA-ARS Feed the Future Bean Team web site.

Nurseries at Zamorano for screening beans for resistance to BGYMV

Dr. Consuelo Estevez made a presentation about the research progress in 'Charcoal Rot' caused by *Macrophomina phaseolina*. She described methods to inoculate with the pathogen at R2 stage of development of the plant. Under experimental conditions inoculations at early stages result in high disease severity and under field conditions disease development follow a long incubation period before symptoms appear during reproductive stages, which is a characteristic of the disease cycle. Results obtained in the BASE 120 panel showed that after inoculation with

conidia, necrotic lesions appear between 7-12 days when plants were inoculated at R2 and that an additional incubation period of 7 -14 days is necessary for pycnidia formation and development of foliar symptoms. There were contrasting reactions between the different genotypes of the BASE 120 panel. The genotypes that exhibited intermediate reactions < 3 were SER 113, SER 125, B14302. SEF 71. Results of the inoculation with CIAT 899 and CIAT 632 in the BASE 120 panel were also presented. Evaluations at 12-21 days after inoculation resulted in greater nodulation for the genotypes: Zorro, ICA Pijao, PR9920-171, ICB-301-204, BFS-139, FBN-1210-48 and FBN-1203-47. These results were consistent with those obtained in field conditions at Isabela where ICA Pijao, ICB-301-204, FBN-1203-47 had superior nodulation over a three-year period.

There was a consensus that the CA/C regional bean research program should be prepared to deal with the negative effects of climate change. In recognition that climate change may not be a priority of USAID, the group discussed alternate themes around which bean research in the CA/C region could be organized. One possibility would be to focus on factors affecting seed quality for markets including: cooking time, washing out and discoloration of seed after the harvest, high nutritional quality, bruchid resistance and super bag for seed storage, protein % and quality, seed type (genetics of high quality seed for CA/C), seed-borne diseases. Another focus could be on bean management including resistance to leafhoppers, bruchids, the bean pod borer. Finally, increased productivity and reduced production costs could be a focus of research including increased seed yield potential and stability, resistance to diseases and pests and biological nitrogen fixation. Tepary bean breeding should be continued to be supported. Lima beans and pigeon peas have the potential to increase grain legume production in Haiti.

The workshop participants discussed future informal training activities. The participants agreed that the PCCMCA meeting should be the site of annual meetings where research results can be shared and collaborative research activities can be planned. Regional tours to visit field trials was deemed a valuable training activity. Informal training in the use of the Integrated Plant Breeding Program was proposed. Dr. Consuelo Estevez proposed a workshop dealing with research protocols for working with bean pathogens in the laboratory. Training in integrated pest management and characterization and use of recommendation domains were also suggested.

Conventional plant breeding was identified by most national bean research programs as a priority for formal training. As previously mentioned, these 'plant breeders' need to be willing and prepared to deal with a wide range of responsibilities including using molecular markers, running a conventional breeding program, screening for resistance to disease, pests and abiotic stress, identifying appropriate crop management techniques, validation of the performance of lines on research stations and farms and producing basic seed stocks. On a regional level, expertise in agricultural economics would help to measure the impact and adoption of technologies and estimate cost of producing beans.

There are several advantages to U.S. Agriculture of continued support of the CA/C regional bean research network. Central America is the center of diversity of the Mesoamerican beans. Collaborative research generates goodwill with partners in CA/C and facilitates access to bean germplasm of great potential value to U.S. bean breeding programs. Central America and the Caribbean serves an outpost were emerging bean diseases and pests can be studied before their arrival on the mainland of the U.S. Climate change may permit diseases that are currently problems in the tropics, such as angular leaf spot, to gain importance in the U.S. Finally, formal training benefits U.S. universities.

The group spent one morning visiting bean field trials at Zamorano. Dr. Rosas demonstrated a simple screenhouse technique that can be used to screen beans for nodulation with *Rhizobium*. He has also established nurseries that can be used to screen lines for resistance to charcoal rot.A total of 450 lines from the third cycle of recurrent selection for web blight resistance are planting in field trials at Zamorano and Puerto Rico. The high and low fertility split blocks in the field have proven to be very effective to identify lines with yield potential and the ability to yield well in lower fertility soils. BGYMV and angular leaf spots were the most common diseases this growing season.

Angular leaf spot

Dr. Rosas describing the low soil fertility nursery