Adapting Agriculture to Climate Change: Collecting, Protecting, and Preparing Crop Wild Relatives (CWR Project)

2019 Technical and Financial Progress Report

Project title: Using Bean populations derived from P. *acutifolius* to advance toward generation of new bean varieties and discerning the traits and genetic base associated to heat tolerance	
Trust grant no: GS19002	**Project reference no:** GS19002
Project starting date: 1 January 2019	**Project end date:** 30 September 2020
Report due date: 31 January 2020	
Period covered by this report: 1 January 2019 – 31 December 2019	
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NB
Please note that the report will be signed only after Crop Trust approval

Table of Contents

Major achievement(s)/ Highlights/ Most exciting findings and experiences of 2019 (100-300 words).

2019

This phase of the project started with germplasm derived from two wild *P. acutifolius* accessions tolerant to heat stress, G40056 and G40287, which was advanced to F2.3 during phase 1. These populations were advanced with two main purposes, generating promising lines to be sent to partners for selection under field heat stress, and to generate a population for genomic analysis aimed at identification of genomic regions responsible for heat tolerance. For the first objective, 128 F3.5 bulks were obtained with a wide range of grain type and the seed will be send to partners for field evaluation and selection. For objective 2, about 34% of F4.5 interspecific families evaluated against heat stress under greenhouse conditions have shown good level of tolerance based on their pod formation capacity.
In addition to research activities, a workshop was held in Palmira in October 2019 where all the methods and tools available at CIAT for heat stress breeding were harmonized among breeders coming from different countries. The content of this workshop included lectures, lab practical sections, and greenhouse and field activities.
The major achievements from the breeding activities are described below:

- A group of families have been selected based on agronomic potential of the F2.3 families derived from wild accessions. They will be evaluated for heat under field conditions in 3 countries (Colombia, Honduras, Mozambique)

- Another group, F3.4 families, are being advanced for heat tolerance evaluation as Recombinant Inbred Lines to identified QTL associated to Heat tolerance.
- These were evaluated as F4.5 families in a preliminary trial in the greenhouse at 23-24C nights, to validate the existence of variability among families for response to heat.
- The same F4.5 families were planted in the field to take F5 individual plant selections in families that maximized variability in heat response and genetic variability as reflected by pedigree analysis
- These F5 families are currently in the greenhouse heat analysis in 4 repetitions, including physiological analysis.

A. Technical Report

1. Narrative summary of progress

Describe progress made in implementing the project from commencement to present. Please ***include brief descriptions of the approach taken and outcomes achieved.***

Progress made in the Project during 2019 is summarized in figure 1.

Project progress Summary

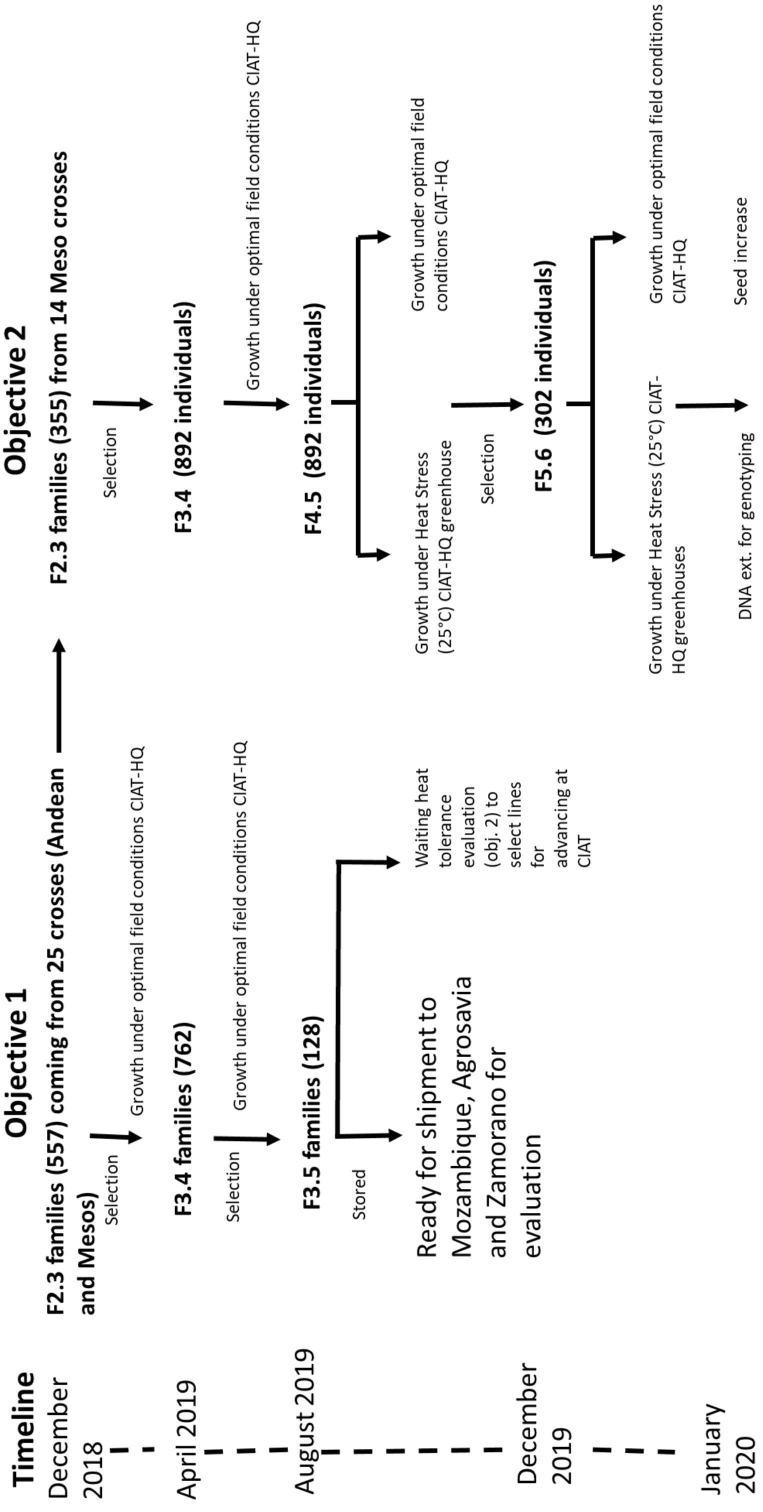

Figure 1. Summary of project execution carryout during 2019.

A F2.3 population obtained in phase 1 was used for further research during phase 2 and its description is shown in table 1.

Table 1: F2.3 families generated during phase1 and used for phase2.

Pedigree description	Amount of families
((VAP 1xG 40056)F1 X DAA 98)F1 X DAB 295	2
((VAP 1xG 40056)F1 X DAB 295)F1 X DAB 317	10
((VAP 1xG 40056)F1 X DAB 317)F1 X DAA 98	14
((VAP 1xG 40056)F1 X DAB 317)F1 X DAB 295	2
((VAP 1xG 40056)F1 X DAB 317)F1 X DAB 317	4
((VAP 1xG 40056)F1 X SEN 118)F1 X ICTA LIGERO	12
((VAP 1xG 40056)F1 X SEN 118)F1 X MAM 38	95
((VAP 1xG 40056)F1 X SEN 118)F1 X SEF 10	42
((VAP 1xG 40056)F1 X SEN 118)F1 X SEN 118	19
((VAP 1xG 40056)F1 X SEN 118)F1 X SMR 155	81
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X ICTA LIGERO	3
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X MAM 38	14
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SEF 10	10
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SEN 118	2
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SMR 155	1
((VAP 1xG 40287)F1 X SEF 10)F1 X ICTA LIGERO	67
((VAP 1xG 40287)F1 X SEF 10)F1 X MAM 38	37
((VAP 1xG 40287)F1 X SEF 10)F1 X SEF 10	15
((VAP 1xG 40287)F1 X SEF 10)F1 X SEN 118	13
((VAP 1xG 40287)F1 X SEF 10)F1 X SMC 214	19
((VAP 1xG 40287)F1 X SEF 10)F1 X SMR 155	70
(VAP 1xG 40056)F1 X DAA 98	7
(VAP 1xG 40056)F1 X DAB 295	1
(VAP 1xG 40287)F1 X MAM 38	16
(VAP 1xG 40287)F1 X SEF 10	1
Total	557

F 2.3 was evaluated at CIAT-Palmira under favorable conditions (figure 2) to select lines using development related features as growth habit, days up to flowering, flower color, days up to maturing, seed color and size.

Figure 2: Sowing time for 557 F2.3 families during February 2019 at CIAT-Palmira station.

Several *P. acutifolius* morphological traits were observed in the F 2.3 population when it was evaluated at vegetative phase. They were mainly related to leaf shape (lanceolated), short internodes, and indeterminate growth habit (figure 3), and they were observed in those populations derived from Mesoamerican crosses. On the other hand, families coming from Andean parents showed Type III growth habit (prostrate), and longer time for reaching physiological maturity. This population was divided into two groups to accomplish two different objectives, first group was used for obtaining promising lines to be sent to partners, and a second group for assembling a mapping population for heat stress for which 202 families from Andean derived families (table 2) were discarded due to their poor performance. Lines showing good agronomic characteristics (figure 4) yielded 762 F3.4 individuals for objective 1. In order to capture as much genetic diversity as possible required for objective 2, a minimum of two plants per family were selected, and their selection should include one with outstanding performance for yield, and another with *P. acutifolius* morphological features. Under this criteria, objective 2 F2.3 population yielded 892 F3.4 individuals.

Figure 3: Plants from F2.3 population showing *P. acutifolius* morphology. A, lanceolated leaves; B, short internodes; C, indeterminate habit growth.

Table 2: Families from Andean background that were discarded for the Genetic analysis objective.

Pedigree	Families discarded
((VAP 1xG 40056)F1 X DAA 98)F1 X DAB 295	2
((VAP 1xG 40056)F1 X DAB 295)F1 X DAB 317	10
((VAP 1xG 40056)F1 X DAB 317)F1 X DAA 98	14
((VAP 1xG 40056)F1 X DAB 317)F1 X DAB 295	2
((VAP 1xG 40056)F1 X DAB 317)F1 X DAB 317	4
((VAP 1xG 40056)F1 X SEN 118)F1 X MAM 38	95
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X MAM 38	14
((VAP 1xG 40287)F1 X SEF 10)F1 X MAM 38	37
(VAP 1xG 40056)F1 X DAA 98	7
(VAP 1xG 40056)F1 X DAB 295	1
(VAP 1xG 40287)F1 X MAM 38	16
Total	202

Fig**ure 4: Examples of selected plants from F2.3 population showing good agronomic traits as plant architecture and pod loading.**

After selection both F3.4 populations, 1 and 2, went through another round of evaluation and selection under optimal conditions at CIAT-Palmira station. For population 1 the selection was mainly based on those families showing including bushy type plant development, good pod formation capacity, and a wide set of grain color. After selection the population number were reduced to 128 F3.5 bulks. The seed of this selection was properly stored and will be sent to partners for testing and further selection. For population 2 the selection was done using the same futures used the previous generation, growth habit, leaf shape, flower color, days to flowering, and days to maturity. This F3.4 population families with *P. acutifolius* and good agronomic properties were observed and the selection for next generation advance was done by collecting a single random plant from each family (figure 5), avoiding bias for any particular feature, and 892 F4.5 individuals were obtained.

Figure 5. Selection at harvesting time at CIAT Palmira field using one random plant from each F3.4 family.

Population 2, at F4.5 generation was used for heat stress evaluation under greenhouse conditions at CIAT Palmira (figure 6) and the same set was planted in the field under favorable conditions for generation advancing. Heat stress trial was established as 25°C during night time maintained during the whole plant cycle, 4 sister plants from each of the 892 families were planted, and SEF 60, SEF 16, AMADEUS y G40111 were included as checks since some potential for heat tolerance has been observed in other trials.

Selection under heat stress was conducted by using photosynthetic parameters measured using MultiSpec device, pod formation data.

Figure 6. Sowing and harvesting plants from F4.5 population submitted to heat stress under greenhouse conditions at CIAT-Palmira.

Pod formation capacity was evaluated using the following qualitative scale: 1, no pod formation; 2, some pod formation; 3, good pod formation; 4, outstanding pod formation (figure 7). Wide variability in this trait was observed in the population as is shown in table 3.

Figure 7. Plants under heat stress. Left, tolerant plant showing outstanding pod formation, right, plant showing poor performance.

Table 3: Description of number of families showing different values on pod formation capacity under heat stress.

Pedigree	No. of Families					
	4	**3**	**2**	**1**	**Dead**	**Total**
((VAP 1xG 40056)F1 X SEN 118)F1 X ICTA LIGERO	2	11	11	6	0	30
((VAP 1xG 40056)F1 X SEN 118)F1 X SEF 10	4	36	54	25	0	119
((VAP 1xG 40056)F1 X SEN 118)F1 X SEN 118	2	11	29	10	0	52
((VAP 1xG 40056)F1 X SEN 118)F1 X SMR 155	15	69	68	38	1	190
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X ICTA LIGERO	1	0	4	4	0	9
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SEF 10	2	5	13	5	0	25
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SEN 118	0	0	2	4	0	6
((VAP 1xG 40287)F1 X ICTA LIGERO)F1 X SMR 155	0	0	2	1	0	3
((VAP 1xG 40287)F1 X SEF 10)F1 X ICTA LIGERO	6	57	65	41	0	169
((VAP 1xG 40287)F1 X SEF 10)F1 X SEF 10	0	10	16	9	0	35
((VAP 1xG 40287)F1 X SEF 10)F1 X SEN 118	2	3	17	10	0	32
((VAP 1xG 40287)F1 X SEF 10)F1 X SMC 214	3	15	20	19	0	57
((VAP 1xG 40287)F1 X SEF 10)F1 X SMR 155	5	45	64	48	0	163
(VAP 1xG 40287)F1 X SEF 10	0	0	2	0	0	2
Percentage	**4.7%**	**29.4%**	**41.1%**	**24.7%**	**0.1%**	**892**

After data analysis susceptible and tolerant families were selected, reducing the numbers to 302 F5.6 families. These families were planted at CIAT-Palmira in December 2019 under heat stress (25°C night temperature) for detailed phenotyping, genotyping and selection, and under favorable field conditions for generation advance and seed production. For heat stress 4 plants per family were planted, and AMADEUS, G40111, Rojo Seda, DOR 390 y SEF 60 were used as checks. The design included a repetition of 30% of F5.6 population. DNA will be extracted from the population in order to obtain genotypic data that will be used for association analyses for heat stress tolerance.

2. Risks encountered and deviations from the project workplan

a) Describe any internal and external risks (e.g., political, operational, natural disasters, weather events, organizational, financial, etc.) that have resulted or could result to deviations from the project workplan.

Contracts with partners have not been signed, revisions between organizations can have an impact on workplan.

b) Explain briefly how activities, methods, strategies and collaborators have had to differ from the original workplan, explaining the consequences of deviations, any necessary additional actions and mitigation strategies that have to be taken as a result.

Activities planned with all three partners will be starting during 2020 and not end of 2019.

3. Capacity building

Please comment on progress on any capacity building under the project. Provide information on the number of persons trained, the country of origin and work affiliation of the trainee and the gender.

In October 2019 CIAT organized a workshop entitle "Upgrade in methodologies and tools used in breeding for heat tolerance in Common beans". Breeders and agronomist involved in bean research from national institutions from Africa and Latin America were invited to this activity, the list of participants is described in the table 4 and pictures of the event are shown in figure 8 and 9.

Figure 8. Heat stress greenhouse visit during workshop to observe evaluation of F4.5 p0pulation.

Figure 9. Seed multiplication under mesh house and field observation visit during workshop.

Table 4. List participants whom attended to the Bean heat stress tolerance training activity held in CIAT-Palmira during 2029.

Name	Nationality	Position	Institution
Celestina Jochua	Mozambique	Agronomist/breeder	Institución de Investigación Agraria de Mozambique - IIAM
Juan Carlos Rosas	Honduras	Breeder	Escuela Agrícola Panamericana Zamorano
Oscar Jair Rodriguez	Colombia	Agronomist	AGROSAVIA
Norman Danilo Escoto	Honduras	Agronomist/Bean research leader	Dirección de Ciencia y Tecnología Agropecuaria-DICTA
Aldemaro Clara Melara	El Salvador	Breeder	CENTA-MAG
Rommel Igor Leon	Colombia	Agronomist	AGROSAVIA
Nestor Felipe Chavez	Costa Rica	Breeder	Universidad de Costa Rica
Ronaldo Calderon	Nicaragua	Agronomist	Instituto Nicaragüense de Tecnología Agropecuaria - INTA

Please complete the information if relevant

List training events attended that were organized under the CWR Project.	Workshop on harmonizing tools and methods used in bean breeding for heat tolerance
Total number of trainees:	**8**
Number of female trainees:	1
List country of origin and the number of trainees per country (in parenthesis) *E.g. Country xxx (4)*	See table 4

4. Information products

List any information products arising from this work and describe where they can be found. We also welcome receiving any photographs of your work that you may be willing to share.

Pictures can be found in the report according to each activity.

5. Publications / Conferences attended / Lectures given

A. Publications

Publications - 2019

List the citations of any scientific papers arising from this work submitted during the reporting period and planned for the next year.

Publication type*	Article title	Publication year	Authors+	Name of the journal	Publication DOI or URL link of the publication
NONE					

**Publication type: 1=Journal, 2=Book, 3=Book chapter, 4=Conference paper, 5=Working paper/Brief, 6=Other. +Mark project staff authors.*

B Conferences attended

Conferences attended - 2019

None

C Lectures given

Lectures given in 2019

None

6. Lessons learned

Reflect on how the project has engaged and strengthened national/institutional capacity in collecting, protecting, and preparing CWR. Summarize significant lessons learned, stating how these lessons could/will be used to improve project performance in the future.

Not at this time.

7. Cross-cutting issues and complementary/linked activities and partnerships

a) Describe any cross-cutting issues (e.g., gender, climate, environment, farmers' rights, policy, etc.) that relate to the CWR project.

None

b) Describe other relevant activities underway or planned that are complementary to the CWR Project in general. Give details of the collaborating institutions, including benefits from institutional partnerships made.

None

8. Others

A Sharing germplasm/ seed distribution

Seeds are ready to be shipped to partners.

B Plan for conservation and availability of germplasm

Not at this stage, this type of activities will be implemented during 2020.

C Managing and sharing information and data

Not at this stage, this type of activities will be implemented during 2020.

D Communication

See annex 2.

9. Progress against Specific Outputs (to be reported on the workplan table)

a) *For each Specific Output in the project workplan overleaf, describe progress to date in column E. For those activities/tasks that were due within the current reporting period, please indicate if these were met and when by completing column D.*

b) *If any activities/tasks due within the current reporting period were not met according to the proposed plan, please indicate the revise due date in column F. If there are major changes to the activities and outputs, please inform us and we will provide you with a template.*

Project Workplan Table

Reporting Period: 01/01/2019 - 31/12/19
Columns A to C have been completed in accordance with the project agreement workplan

A	B	C	D	E	F
Outputs	**Activities/tasks**	**Due Date**	**Actual Completion Date**	**Commentary on Progress to Date**	**Revised Due Date (if necessary)**
1. Obtain advanced heat tolerant lines derived from crosses between P. acutifolius and bean lines with commercial grain types					
1.1 F4 populations segregating for heat tolerance families with commercial grain types and tropical adaptation	Activity 1.1. Production of F4 families from interspecific crosses for subsequent selection of heat tolerance and agronom ic traits.	Apr 2019	Apr 2019	Completed	
1.2 Seeds from heat stress tolerance lines certified for international shipment	Activity 1.2. Evaluation of F4 families for heat tolerance to select F5 families.	Jul 2019	August 2019	Generation advance were done without selection under heat stress, just agronomic traits were used.	
1.3 Researchers working on heat tolerance of bean have common standards and criteria	Activity 1.3. Developing shared capacity and criteria for selection of heat tolerance.	Sep 2019	October 2019	Heat stress evaluation process was shared with breeders in a workshop held in CIAT Palmira	
1.4 Agronomic data contributed to CIAT's public database	Activity 1.4. Evaluation of selected families for other traits in	Aug 2020	Pending		

	the mainstream breeding program.				
1.5 Bean lines characterized under field conditions in Mozambique, Honduras and Colombia for heat stress	Activity 1.5. International evaluation of families for heat tolerance.	Aug 2020	Pending		
1.6 Promising bean lines tolerant to heat stress promoted among local farmers and breeders	Activity 1.6. Participatory evaluation of selected lines with farmers.	Jul 2020	Pending		
1.7 Target regimes defined	Activity 1.7. Analyzing climatic parameters to characterize research and target environments.	Aug 2020	Pending		
Objective 2: Design and implement a crossing and phenotyping plan aimed to dissect the genetic base of heat tolerance of P. acutifolius					
Genetic resources based on introgression of genes from P. acutifolius to the common bean genome	Activity 2.1. Development of Recombinant Inbred Lines (RILs) for genetic studies and QTL analysis.	Sep 2019	August 2019	F4.5 Population for genomic analysis was obtained and now is at F5.6.	
Phenotypic data for reaction to heat stress on RILs	Activity 2.2. Evaluation of heat stress and other traits on RILs.	Apr 2020	December 2019	A first round of evaluation-selection was done and results were obtained from F4.5 generation. A second	

				round of evaluation/selection is under progress on F5.6 generation.	
Genotypic profile of RILs	Activity 2.3. Genotyping of RILs for QTL analysis.	Mar 2020	Pending	DNA will be extracted in January 2020 from F5.6 population for genotyping.	
Identification of QTL associated to heat tolerance	Activity 2.4. QTL analysis performed on RILs for heat tolerance.	Aug 2020	Pending		

B. 2019 Financial Progress Report

Please see Annex 1 (Excel sheet) for the financial report template and instructions for completing it.