The contribution of CIAT genebank to biofortified beans and farmers' welfare in Rwanda

Stefania Sellitti, Kate Vaiknoras, Melinda Smale, Nelissa Jamora, Robert Andrade, Peter Wenzl and Ricardo Labarta

Email: stefaniasellitti@outlook.com

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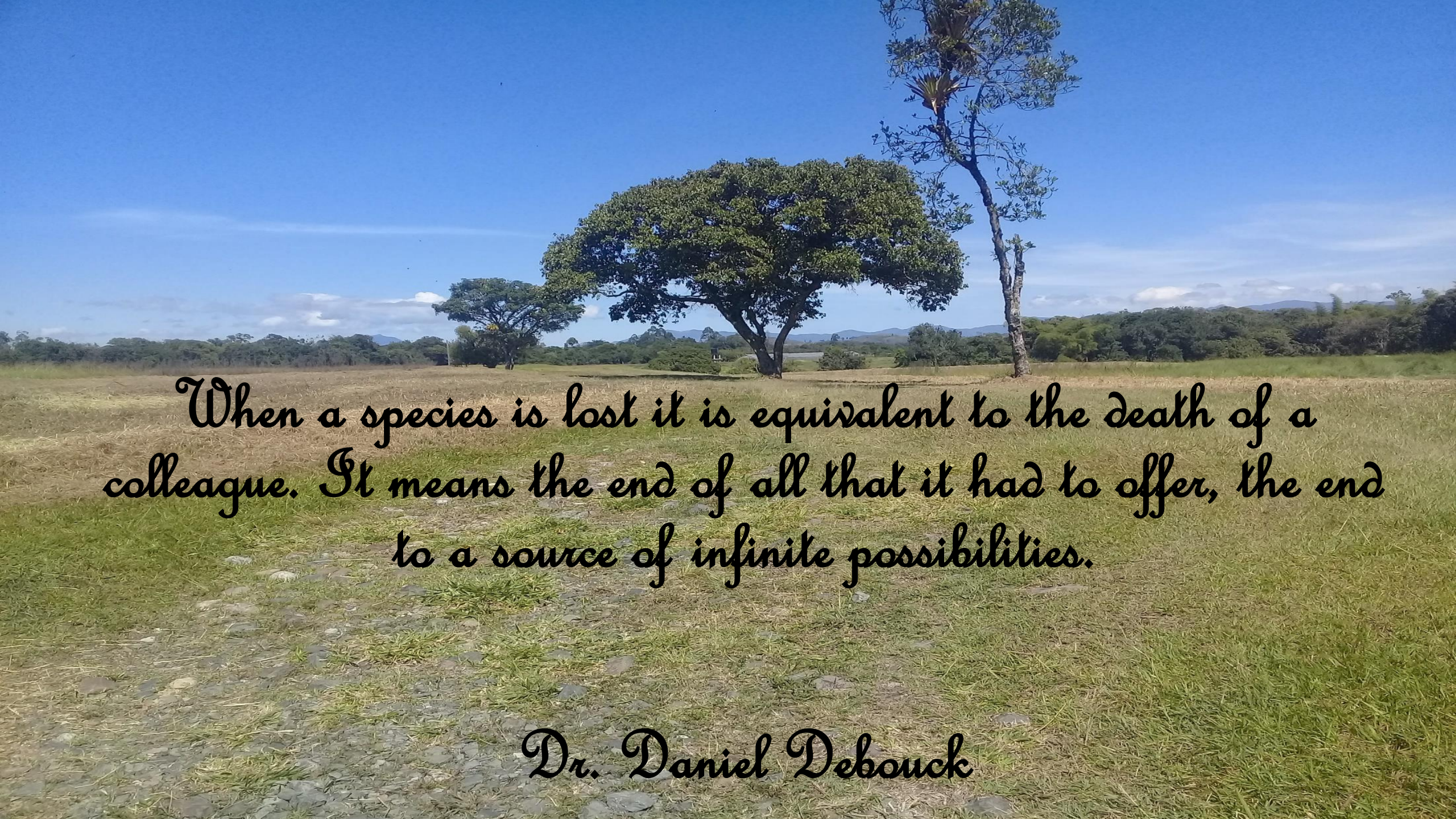
Centro Internacional de Agricultura Tropical
Desde 1967 Ciencia para cultivar el cambio

CGIAR Genebank Platform


When a species is lost it is equivalent to the death of a colleague. It means the end of all that it had to offer, the end to a source of infinite possibilities.
Dr. Daniel Debouck

Background

ABOUT GENEBANKS	ABOUT RWANDA AND BEAN CONSUMPTION
• Genebanks play an essential role in the safeguard of agricultural biodiversity. • CIAT's genebank is one of the eleven international CGIAR genebanks. • CIAT conserves the world's largest collection of beans, cassava and tropical forages, composed of 37,987 bean accessions, 6,643 cassava accessions and 23,140 tropical forages accessions. • CIAT's genebank has distributed more than half a million samples from 141 countries to requesters in more than 160 countries.	• About 400 million people in the tropics eat beans as part of their daily diet. • Beans provide a highly nutritious food, containing protein, fiber, complex carbohydrates, vitamins, and micronutrients. • Beans are an indispensable source of iron, containing about 8mg of iron in 100g. • In Rwanda, around 29 kg of beans are consumed per person per year, the highest consumption in the world (Palmer, 2014).

Research question and objectives

"How do genebanks play a role in the improvement of nutrition quality of food crops?"

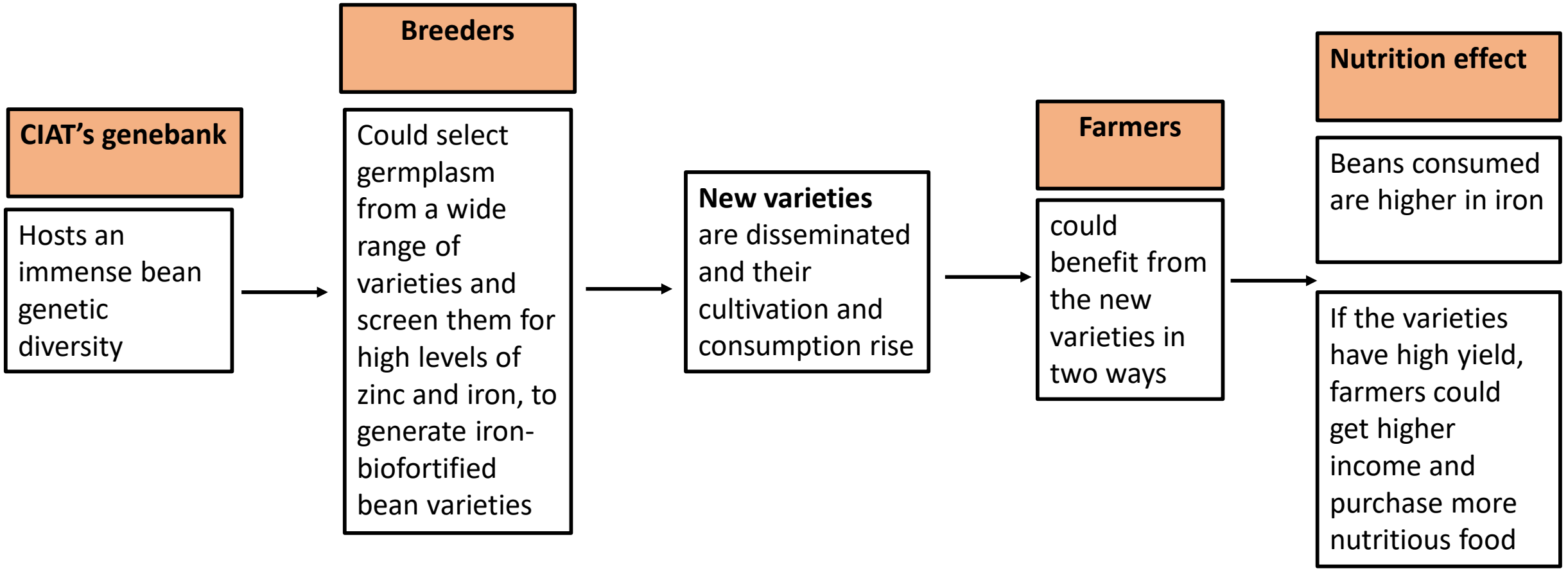
Problem

Genetic diversity is essential in the development of biofortified crops. Although germplasm from CIAT's genebank have been extensively used in research and as parents in breeding programs, the links between the original genebank accessions and the improved varieties grown by farmers have not always been documented.

Main objective

To assess the contribution of the CIAT genebank to the development of biofortified bean varieties and their impact on the well-being of farm households in Rwanda.

Theoretical impact pathway



Data and methods

FROM GENEBANKS TO BREEDERS	FROM BREEDERS TO FARMERS
• We traced the *"journey"* of bean accessions from their collection and introduction into the genebank to their distribution and use in Rwanda. • We linked 7 iron-biofortified climbing varieties introduced in Rwanda **(CAB2, RWV3316, RWV3317, RWV3006, RWV2887, MAC44, MAC42)** directly to CIAT's genebank through pedigree analysis and key informant interviews with the breeders who developed them.	• We estimated the impact of bean adoption on production and consumption of farm households in Rwanda, drawing from a nationally representative data on bean producers in Rwanda collected by Harvest Plus, in partnership with RAB and CIAT. • We used econometric methods, such us OLS, IV, CF approach, Poisson model, Zero-inflated Poisson.

Data sources and data collection

FROM GENEBANKS TO BREEDERS	FROM BREEDERS TO FARMERS
Pedigrees analysis • Research of past literature. • Research in the annual reports of CIAT's bean program. • Personal communication with bean breeders in Rwanda and at CIAT. • Use of the Pan-Africa Bean Research Alliance (PABRA) website. • Use of the *Catalogue of advanced bean lines from CIAT* by M.A. Rodriguez et al. (1994) available at CIAT's library. • Use of the database of the Bean Program of CIAT	**Data collection** • Data were collected in two stages in 2015. • First round (May 2015): 19,575 households were interviewed regarding their history of adoption of iron-biofortified bean varieties. • Second round (September 2015): twelve households from each village were randomly selected for the main household survey, for a total of 1,397 interviews. • This analysis considers only those farming families who grew either local bean varieties or at least one iron-biofortified climbing variety in 2015 that could be directly traced to CIAT's genebank.

Empirical framework (1)

DEPENDENT VARIABLES

- Yield
- Number of months prior to the survey during which households consumed beans from their own harvests.
- Average quantity per adult male equivalent
- Number of months in which households had to purchase beans in the market
- Average quantity purchased in kg.

IMPACT ON YIELD

$$\boldsymbol{Y_{it} = \alpha + \beta T_{ij} + \gamma I_{ij} + \delta H_i + \varepsilon_{ij}}$$

Y = **Yield,** measures as quantity ob beans harvested/quantity of vean planted
T = Treatment dummy variable
I_{ij} = agricultural inputs used in bean cultivation and characteristics of the plot
H_i = household-level variables

Econometric methods

- Ordinary least square (OLS)
- Instrumental variable (IV)
- OLS with control function approach

Empirical framework (2)

IMPACT ON OTHER VARIABLES

$$O_i = \delta_0 + \delta_1 A_i + \delta_2 H_i + \varepsilon_i$$

- O_i: depent variable:
  - **Bean consumption from own-production and purchases**
    - Number of months household consumed beans from own-production (or purchases)
    - Average monthly quantity (in Kg) consumed from own production (or purchases)
  - A_i : Household grew and iron-biofortifies climbing variety in 2015A, 2015B, or both (1=yes)
- H_i: Household-level covariates

Econometric methods

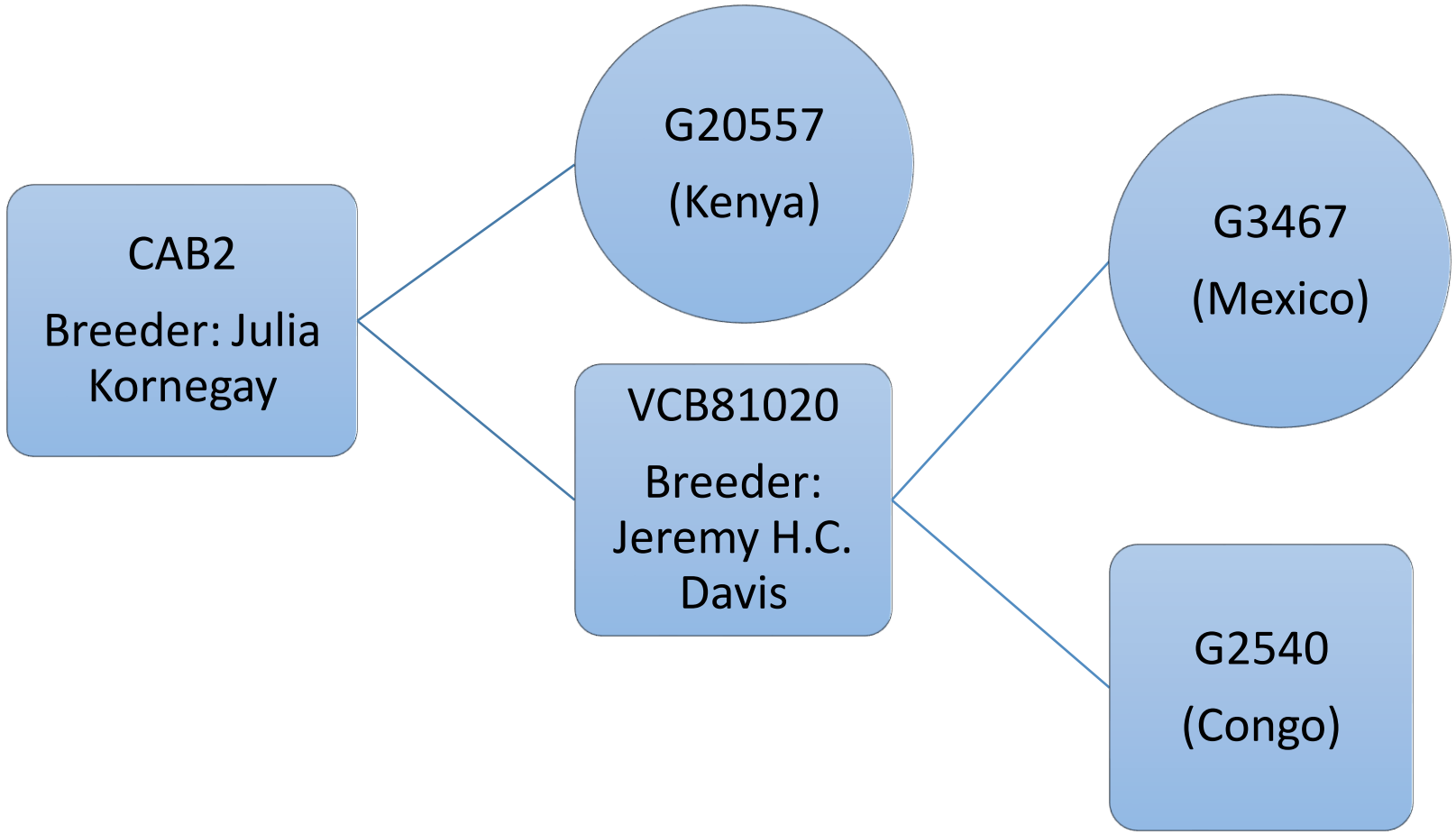
- Ordinary least square (OLS)
  - Poisson model
- Poisson model with CF approach
  - Zero inflated Poisson

Results (1): pedigree analysis

MAC42 and MAC44 were developed using 12 genebank accessions: G12722, G21720, G6616, G4523, G76, G6533, G14013, G11891, G4505, G5704, G4452, G5709 (with country of origins from Colombia, the Dominican Republic, United States, Brazil, Mexico and Peru).

RWV3316, RWV3317, RWV3006, and RWV2887 are the result of the combination of the variety CAB2, developed at CIAT by Julia Kornegay, with either a local Rwandan variety or another CIAT's bred variety.

CAB2 is an important progenitor in the development of iron-biofortified varieties in Rwanda. It was the result of breeding between the genebank accession G20557 and the improved variety VCB81010 of Jeremy H.C. Davis, whose progenitors were G3467 and G2540 from CIAT's genebank. G20557 is a bush variety from Kenya, G3497 is a climbing variety from Mexico, and G2540 a climbing variety from Congo.


CAB2
Breeder: Julia Kornegay
G20557
(Kenya)
VCB81020
Breeder: Jeremy H.C. Davis
G3467
(Mexico)
G2540
(Congo)

Results (2): Econometric analysis

Model	On yield
OLS	0.156
IV	0.982
IV (ML)	0.336
CF OLS	0.078*

(measured as quantity of beans harvested/quantity planted)

Model	On bean consumption	
	Months consumed from own production	Quantity (kg) consumed each month
OLS	0.146	-0.065
Poisson	0.020	
CF Poisson	0.114	
CF OLS		-0.047

Model	On bean purchase	
	Months bean purchased	Quantity (kg) purchased each month
Zero-inflated Poisson	0.146	
Zero-inflated Poisson CF	0.020	
OLS		-0,095
CF OLS		-0,115

Challenges

- Gathering information on pedigrees was a difficult activity. Much of the information about the breeding process that led to the development of iron-biofortified varieties has been lost. In the early days, written documentation has not been standardized and much information is recorded only in the memories of experts.
- Communication between CIAT's genebank and bean breeders is sporadic and there is no feedback process in the use genebank materials.
- We found a weakly significant effect of climbing beans on yield, using the same estimation models and variates applied by Vaiknoras and Larochelle (2018) for bush beans.

Conclusions and ideas for the future

- We were able to assess the role that CIAT's genebank played in the long journey that led to the development of iron-biofortified varieties.
- Future impact studies should account for the full pathway -- from genebank, to breeding, to farm-level adoption – to highlight the need for long-term investment in food security and nutrition.
- Breeding and development process of improved varieties could be accelerated with enhanced collaboration and more active exchange of information between breeders and genebanks.
- Further analysis is necessary to understand the differential effects of bush and climbing bean varieties.

Main references

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Thank you for your attention!