




**WORLD COFFEE<sup>TM</sup>  
RESEARCH**

A close-up photograph of a person's hand holding a small coffee seedling. The seedling has several vibrant green leaves and a small amount of dark soil attached to its roots. The background is a blurred greenhouse filled with rows of similar coffee plants. The lighting is bright and natural, suggesting an indoor growing environment.

**The future of coffee.**

**ANNUAL REPORT  
2016**



*WCR is science to save coffee. It's  
that simple, that vital. No single  
country, no single company can do this;  
that is why our basis is collaborative,  
our successes open source.*

**— Doug Welsh, WCR Board Member &  
Roastmaster, Peets Coffee & Tea**

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## About This Report

This report covers the period between January 1, 2016 to December 31, 2016.

# WHO WE ARE

We are the coffee industry's global research team. A collaborative, precompetitive research organization, we were formed in 2012 by the coffee industry to ensure the future of coffee in the face of threats like climate change. Meet our team on p. 58.

## MISSION

To grow, protect, and enhance supplies of quality coffee while improving the livelihoods of the families who produce it

## IMPACT

Coffee producers are the stewards of both quality and productivity. To enhance their livelihoods and ensure coffee's future, we must provide farmers and industry with better solutions: Better data about what works and what doesn't, better coffee plants, better tools to fight diseases and pests, and better approaches for climate change adaptation.

The fastest, most sustainable way to achieve this is through collaborative research. World Coffee Research brings together scientists from around the world to create new knowledge about the constraints on quality and productivity, identify the "best bang for the buck" solutions, and ensure that results get to farmers.

We use advanced and applied research in the areas of **agronomy, phytopathology, genetics and genomics, breeding, sensory and chemistry science**, and **socioeconomics** to help coffee producers become more resilient and profitable, especially in the face of significant threats like climate change and pests and diseases.

### Our research delivers:

- ✓ **Higher quality coffee**
- ↑ **More productive coffee farms**
- \$ **Higher profits for farmers**

## MAIN CHALLENGES

There are a number of challenges that the global coffee industry faces today.  
*At World Coffee Research we focus our efforts on:*



Lifting **farmer profitability**



Preparing for **climate change**



Protecting and increasing **quality**



Controlling rust and other **diseases**



Measuring coffee plants at the WCR Research Farm in El Salvador. Source: Salvador Urrutia Loucel

# HOW WE WORK

## COLLABORATIVELY

We don't do this work alone. We collaborate with core partners in producing countries and the best minds in coffee science and other scientific fields, wherever they are. See a full list of our partners on p. 58.

## GLOBALLY

Most of our research is done in the places where coffee is grown. We partner with local research institutions, coffee organizations, governments and NGOs, ensuring maximum impact.

In 2016, over **50** organizations assisted in carrying out our research through collaborative execution

## OPENLY

Our work benefits the entire coffee industry, and especially the coffee farmers who are the stewards of coffee quality and productivity.



## OUR STRATEGY



### Create new technologies

- New, high quality, disease resistant, climate resilient varieties, including:
  - F1 Arabica hybrids
  - Interspecific hybrids (Arabica x Robusta)
  - Robusta varieties for Arabica rootstock grafting

### Enable technologies to be more efficient

- Conserve and utilize coffee genetic diversity through genebank preservation and establishing new breeding pools
- Identify key genes to target in molecular breeding
- Create needed tools for targeting quality through chemistry and sensory analysis

We do advanced research and development **through universities and other institutes** in coffee producing and consuming countries.





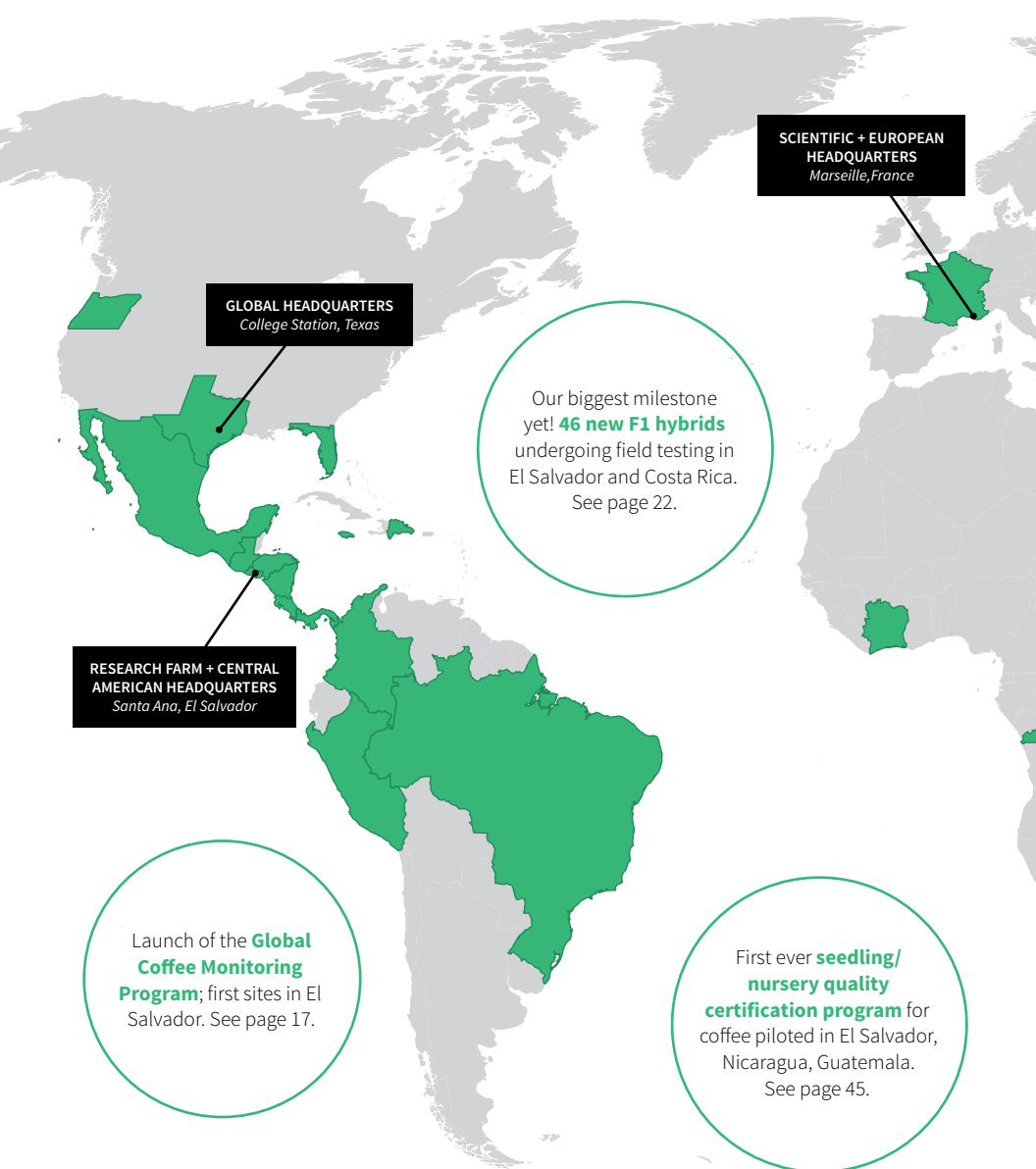
## **Boost** the use of existing technologies

- Build a global network of scientific on-farm trials to show farmers the ROI of improved varieties and soil treatments (Global Coffee Monitoring Platform)
- Develop new tools to increase farmer knowledge of varieties and rust control practices (Rust Manual, Coffee Varieties Catalog)
- Establish global seed exchange platform for world's best varieties (International Multilocation Variety Trial)
- Create world's first quality assurance program for seedlings and nurseries (WCR Verified)

We work **directly with coffee institutions and partners in producing countries** to boost the use of good technologies in farmer fields.

# WHERE WE WORK

## 2016 HIGHLIGHTS



**GLOBAL HEADQUARTERS**  
*College Station, Texas*

**SCIENTIFIC + EUROPEAN HEADQUARTERS**  
*Marseille, France*

**RESEARCH FARM + CENTRAL AMERICAN HEADQUARTERS**  
*Santa Ana, El Salvador*

Our biggest milestone yet! **46 new F1 hybrids** undergoing field testing in El Salvador and Costa Rica. See page 22.

Launch of the **Global Coffee Monitoring Program**; first sites in El Salvador. See page 17.

First ever **seedling/nursery quality certification program** for coffee piloted in El Salvador, Nicaragua, Guatemala. See page 45.

## In 2016, our work took us to 27 countries:

Australia, Brazil, Colombia, Costa Rica, Cote D'Ivoire, Democratic Republic of Congo, Dominican Republic, El Salvador, Ethiopia, France, Guatemala, Honduras, India, Indonesia, Jamaica, Kenya, Laos, Madagascar, Mexico, Nicaragua, Panama, Papua New Guinea, Peru, Rwanda, United States, Zambia, and Zimbabwe



Field visits to Brazil, Colombia, Madagascar, Cote d'Ivoire, Kenya, Ethiopia, and Costa Rica to survey the **world's most important coffee collections** for a global conservation strategy. See page 41.

**Four new countries added to the International Multilocation Variety Trial:** Australia, Rwanda, the US, and Zimbabwe. See page 43.



## **DELIVERED IN 2016**

***Coffee Varieties of Mesoamerica and the Caribbean***

***Prevención y Control de la Roya del Café***

***Scientific Publications***

# Coffee Varieties of Mesoamerica and the Caribbean

*An essential new resource for farmers and industry*



The decision farmers make about which variety to plant has long-term consequences that last until the next generation. **Coffee farmers should be able to make informed decisions about which variety will work best for their situation and needs.** That's why World Coffee Research created this catalog of 33 key varieties for a region devastated by coffee leaf rust.

This interactive website and PDF catalog includes profiles of newly developed F1 hybrid varieties like Centroamericano, as well as traditional varieties like Caturra, Bourbon, and Geisha and wide range of rust-resistant varieties. All of the varieties included in the catalog are non-GMO.

Online catalog accessed  
**15,673** times in 2016

**19,800** printed copies  
distributed in Central America

In 2017, we will publish an expanded catalog covering African and additional Central American varieties.

**Available free online at:**  
[varieties.worldcoffeeresearch.org](http://varieties.worldcoffeeresearch.org)

# Prevención y Control de la Roya del Café

## *A thorough and accessible guide for agronomists and technicians*

This technical guide about coffee leaf rust covers the *Hemileia vastatrix* organism, different methods of controlling rust, and best practices for transmitting information to coffee producers. Compiled by experts at the Tropical Agricultural Research and Higher Education Center (CATIE) in collaboration with WCR, with funding provided by USAID.

Available in Spanish only. In 2017, WCR and its partners will publish a simplified, illustrated version for farmers.



**Available free online at:**

[worldcoffeeresearch.org/roya-manual](http://worldcoffeeresearch.org/roya-manual)

## Two New Coffee Research Centers Debut in 2016

The prospects for cutting-edge research on coffee—from seed to cup—got better in 2016 with the launch of two new centers of academic research.



Texas A&M Center for Coffee  
Research and Innovation  
[coffee.tamu.edu](http://coffee.tamu.edu)



UC Davis Coffee Center  
[coffeecenter.ucdavis.edu](http://coffeecenter.ucdavis.edu)

## Scientific Publications

World Coffee Research-affiliated scientists presented multiple papers at the biennial International Conference on Coffee Science, held in Kunming, China on November 14–18, 2016.

- **On Arabica genetic diversity.** An extensive study of the genetic diversity of Arabica coffee reveals two subpopulations in Ethiopia and a cultivated subpopulation in Yemen. Klein P., Murray S., Solano W., Montagnon C., Schilling T., Bertrand B. See also page 23.
- **On climate change adaptation.** Effectively guiding forward looking climate change adaptation of global coffee supply chains. Bunn, C., Läderach, P., Lundy, M., Montagnon, C., Mosnier, A., Obersteiner, M. See also page 38.
- **On plant stress, rust and quality.** Thinning effect on rust incidence and quality for two varieties of *Coffea Arabica* in Costa Rica revealed by the WCR Sensory Lexicon, GC-MS and SPME. Echeverria, F.; Murray, S.; Klein, T.; Miller, R.; Kerth, C.; Lombardini, L; Bertrand, B. See also page 33.

Abstracts available online at: [worldcoffeeresearch.org/asic2016](http://worldcoffeeresearch.org/asic2016)

Two scientific papers related to the World Coffee Research Sensory Lexicon were published in peer reviewed academic journals in 2016. Both articles were published open access and are freely available to all.

- **On the creation of the WCR Sensory Lexicon.** Chambers, E. IV, Sanchez, K., Phan, U.T.X., Miller, R., and Civille, G.V. 2016. Development of a “Living” Lexicon for Descriptive Sensory Analysis of Brewed Coffee. *Journal of Sensory Studies* 31: 465–480. DOI: 10.1111/joss.12237
- **On the creation of the Coffee Taster’s Flavor Wheel.** Spencer, M., Sage, E., Velez, M., and Guinard, J-X. 2016. Using Single Free Sorting and Multivariate Exploratory Methods to Design a New Coffee Taster’s Flavor Wheel. *Journal of Food Science* 81(12): S2997–S3005. DOI: 10.1111/1750-3841.13555

Full text articles available online at: [worldcoffeeresearch.org/sensory-publications](http://worldcoffeeresearch.org/sensory-publications)



A photograph of a coffee plantation on a hillside. The coffee plants are arranged in neat rows, and the background shows a clear blue sky with a few trees and utility poles. A white rectangular box is overlaid on the center of the image, containing text.

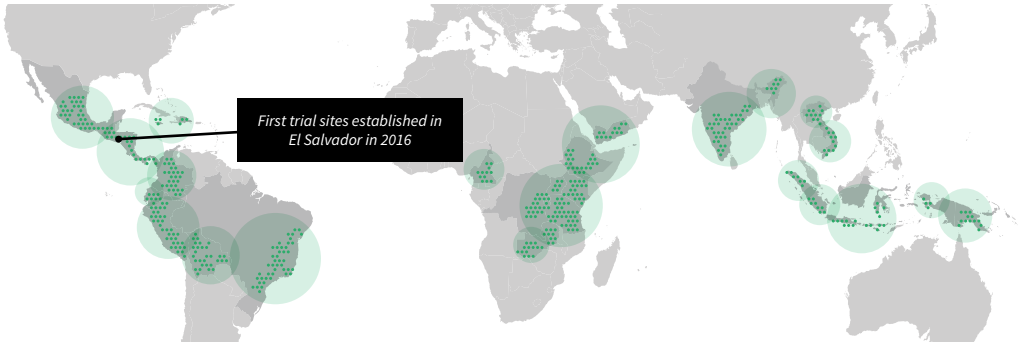
**LAUNCHED IN 2016**

***Global Coffee Monitoring Program***



# Global Coffee Monitoring Program

*An unparalleled platform for transforming coffee farms into climate-smart, productive and profitable enterprises*



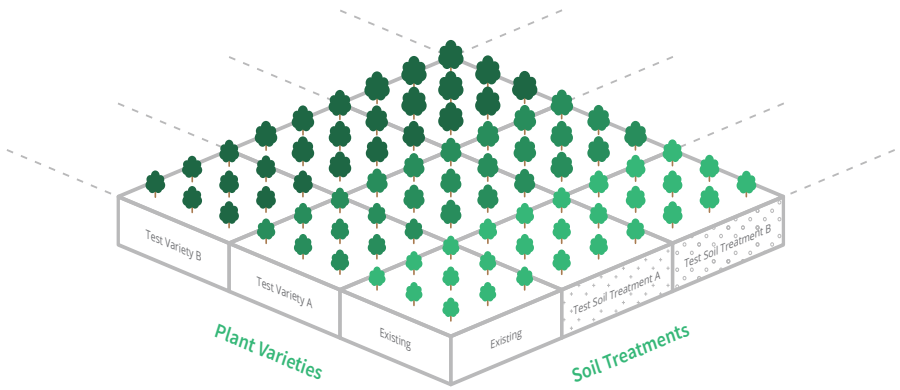
In 2016, WCR launched its most ambitious project yet, the Global Coffee Monitoring Program. Between now and 2022, World Coffee Research will enlist the assistance of dozens of partners—from coffee companies, to NGOs, to national coffee institutions—to install a network of hundreds of scientifically designed research plots in farmers’ fields around the world.

**1100** trial sites planned for farmer fields in **20** countries

**12** trial sites established in 2016



The first trial site was established in Ahuachapán, El Salvador at the Tio Chelo farm, testing the Centroamericano and Marsellesa varieties. Source: Francisco Anzueto



At each on-farm technology trial (OFTT) site, participating farmers implement climate-smart technologies (two improved coffee varieties and two soil treatments) to test against the farmer’s current practice. After five years, the farmer—and the industry—will have climate and performance data about which varieties and soil treatments improved their profitability the most. These are numbers farmers can literally take to the bank to show creditors the value of renovating their farms and investing in improved technologies. Participating farmers will host Farmer Days to showcase their plots to neighboring farmers, initiating a ripple effect of improved performance across the globe.



We work with farmers to determine which varieties and soil treatments are most profitable.  
Source: David Laughlin

# This global network of hundreds of climate-smart farms will produce big data for coffee and big gains for producers



## Smarter Farming

Significant advances in knowledge and awareness about coffee variety performance, soil treatments, and farming practices.



## Lifting Profitability

Unparalleled data supporting improved farm profitability and helping farmers secure loans for renovation.



## Boosting the Use of Better Plants

Accelerated adoption of new varieties that are high quality, higher yielding, and disease resistant. Data to support investment in large-scale renovation projects will boost the global supply of high quality coffee.



## Monitoring Platform

Track the impact of climate change on the quality and production of coffee as well as the movement of diseases and pests around the world.

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## PARTNER WITH US

Bring smarter farming and improved livelihoods to your supply chain. Contact us at [info@worldcoffeeresearch.org](mailto:info@worldcoffeeresearch.org) to talk with us about sponsoring trial sites.

**Current partners:** ECOM, Mercon, Sucafina, Volcafe, Keurig, Catholic Relief Services, IHCAFE, USAID



## **ONGOING PROJECTS**

***Improving Coffee Through Breeding***

***Coffee Leaf Rust in Central America***

***Preparing for Climate Change***

***Genetic Resources Conservation***

***International Multilocation Variety Trial***

***WCR Verified Plants***

***Flor Amarilla Farm***

***Kahawara Bora Ya Kivu***

# Improving Coffee Through Breeding

*Our biggest milestone yet—our first F1 hybrid varieties*



Coffee breeder Benoit Bertrand with baby F1 hybrids plants in the nursery. Source: Sara Bogantes

Today's best coffee varieties are no match for the environmental threats of the 21st century—changing weather patterns, increased temperatures, and new disease and insect prevalence. This creates conditions for a potentially disastrous decline in supply in the coming decades. **Focusing on coffee genetic improvement through the breeding of new varieties and advanced research in the lab to identify key genes and markers is vital to ensure the future of coffee.** This is the cornerstone strategy of our work.

Around the world, less breeding on coffee is done now than 50 years ago, but the threats now are greater

In fact, coffee is one of the most under-innovated crops in the world. Today, less breeding is done on coffee than on watermelons! World Coffee Research's breeding program is the only international, precompetitive coffee-breeding program in the world.

## Experimental F1 hybrids in the field

In 2016, we established trials of **46 new F1 hybrids**, derived from crosses between 8 wild Arabicas in the WCR Core Collection and three rust-resistant Sarchimor varieties (Obatá, Marsellesa and IAPAR 59) as well as Geisha. (What is an F1 hybrid? See box on page 26.)

### 46 new F1 hybrids created in 2016 for field testing

These new F1 hybrids will be studied in the field for 4–5 crop cycles, between 2017 and 2021. The best hybrids (probably 2 or 3 in total) will be selected and released for farmers in Central America in time for vegetative multiplication on a commercial scale in 2023. The varieties will also begin testing in Rwanda in 2017.

Varieties will be selected on the basis of:



**High, stable yields**



**Resistance to diseases like leaf rust**



**Cup quality**



**Climate resilience**

#### NO GMO

WCR never uses genetic modification technology



Researchers take pollen from Arabica trees at CATIE. Source: Benoit Bertrand

## The WCR Core Collection

For each of our new hybrids, one of the parents was taken from the WCR Core Collection. This is a collection of 100 highly genetically diverse Arabica varieties, most of which were originally collected in Ethiopian coffee gardens and forests in the 1960s and 1970s and distributed to coffee collections around the world. A genetic diversity analysis in 2015 led to the creation of the Core Collection; it represents the three major genetic groups of Arabica coffee. In 2016, the seeds for the collection were germinated and planted in fields in in three diverse locations: At CATIE (650 meters) and Finca Alsacia (the Starbucks Research Farm, 1350 meters) in Costa Rica, and at the WCR Farm in El Salvador (1000 meters). Plants at each site will be evaluated throughout the next five years.

**100** Arabica types in the Core Collection, **8** used in creating new F1 hybrids

**13,463** trees in **3** locations

## Arabica genetic diversity

Arabica coffee production in the Americas and Asia is based almost entirely on cultivars developed decades ago from a narrow genetic base, leaving coffee extremely vulnerable to threats like diseases, pests, and climate change. These threats have made it clear that novel genetic diversity is badly needed for future breeding. ‘Wild’ Arabica coffee collected in the evolutionary center of origin, Ethiopia, in the middle 20th century contains essential diversity that has not been explored in breeding programs.

Novel genetic diversity is badly needed for future breeding

To understand the genetic diversity of Arabica, World Coffee Research completed the first genome-wide study of Arabica. In the study, 699 *C. arabicas* collected in Ethiopia and 95 *C. arabicas* collected in Yemen were analyzed using a genotyping by sequencing (GBS) approach to determine the relatedness and genetic structure of the plants—like a family tree analysis of the species. The results indicate there are three main genetic groups for Arabica. This genetic diversity structure appears strongly supported by geographic and historic accounts of coffee’s spread around the world.

**3** major genetic groups for *Coffea arabica* identified

Three major genetic groups of *C. arabica* were identified:

1. Group 1: Mainly cultivated types, including Bourbon/Typica-derived cultivars and coffees originating from Yemen and the Harar region of Ethiopia
2. Group 2: Cultivars originating from Tippi and Sheko forest in western Ethiopia
3. Group 3: Cultivars originating from Jimma and Bonga in southwestern Ethiopia

Crucially, the two western subpopulations could represent a novel and important source of valuable genetic diversity for coffee improvement. These results were presented at the International Conference on Coffee Science (ASIC) conference in Kunming, China. A peer reviewed paper is forthcoming in 2017. Also in 2017, researchers will work to identify “gold standard” simple sequence repeat (SSR) markers for the rapid, accurate identification of varieties.



Ph.D. student Fabián Echeverría Beirute holds green coffee beans that will be ground up for RNA extraction. Source: Hanna Neuschwander

## **Molecular breeding**

Molecular breeding is an approach that can cut in half the time it takes to develop new varieties. But in order for molecular breeding to work, scientists must first correlate the *phenotype* of a plant (observable characteristics, such as plant height, yield, etc.) with its *genotype* (the specific genes and markers present in the plant) to discover which are the most important genetic components to target in breeding. This is the first step in launching a robust molecular breeding strategy, and in coffee the work is just beginning.



Postdoctoral research associate Bárbara Castanheira Ferrara Barbosa is doing just that. Barbosa is working in collaboration with Nicafrance, owner of the La Cumplida farm in Nicaragua, which hosts an F2 (second generation) population of over 350 plants that are showing intriguing variations. Since 2011, researchers have collected phenotypic data about observable differences in key traits—including rust, color of young leaves (bronze or green), growth habit (dwarf or normal), height of the tree, cherry production, weight of empty fruits, weight of wet green coffee, and pollen production (fertility/sterility). Barbosa will trace these variations back to the plants' genotypes, in an attempt to identify which genes and markers control their expression. To do this, Barbosa is collecting and adding genotypic data for the plants using a technique that involves sequencing regions across each plant's genome for the development of genetic markers.

In 2016, Barbosa began her genotypic analysis: 384 leaf samples were collected in Nicaragua and shipped to the United States for DNA extractions; 71 DNA samples were sequenced and over 185 million 125bp sequence reads were obtained. In 2017, she will sequence 284 remaining DNA samples and the resulting data will be used to identify genetic markers for the construction of a linkage map. The linkage map will connect genotypic data with phenotypic data to look for markers associated with key desirable traits. By correlating the phenotypic and genotypic data, Barbosa and World Coffee Research can expedite breeding efforts via marker-assisted/molecular breeding, thus leading to the rapid development of more advanced hybrids.

## **Arabica x Robusta hybrids**

Our breeding strategy will expand in 2017 to include the creation of new “interspecific hybrids”—Arabica varieties that contain “introgressed” genes from the *C. canephora* (Robusta) species. The most famous interspecific hybrid is the Timor Hybrid, a 100-year-old spontaneous cross between Arabica and Robusta that has formed the backbone of all modern Arabica coffee breeding for coffee leaf rust resistance. World Coffee Research will be exploring a strategy for the creation of new interspecific hybrids with global partners. The goal will be to maintain desirable traits like leaf rust resistance, without negative associated traits like low cup quality. World Coffee Research will work with an existing population of F2 second-generation hybrids to create new rootstock cultivars and, over the next 10 years, new Arabica F1 hybrids through back-crossing.

Also in 2017, World Coffee Research will explore grafting high quality Arabica varieties onto drought- and pest-resistance Robusta rootstocks, one possible solution for adaptation to climate change.

## The history and future of coffee breeding

Over the last 100 years, Arabica coffee has been slowly “improved” through the simple selection of plants with the best traits. Since the 1990s, coffee breeding has advanced with the introduction of more efficient technologies like DNA sequencing to target traits like yield, quality, and disease resistance, and with the introduction of more genetic diversity. These advances allow modern researchers to leapfrog over decades of underinvestment in coffee breeding.

1930–1960	Massal selection in Africa, Asia, Latin America	Typica- and Bourbon-derived varieties
1960–1980	Pure lines adapted to the “green revolution” for high yields	Caturra, Catuai
1970–2010	Disease-resistant varieties with introgressed Robusta genetics	Catimor- and Sarchimor-like varieties
1990s–present	F1 hybrid varieties for high yield, disease resistance, and quality	Centroamerica, Milenio, Evaluna
The future	Rapid development of improved F1 hybrids through molecular breeding	

**Better coffee trees for farmers and consumers.** The future of coffee breeding lies at the intersection of traditional approaches and modern science and technology, which can be used to create new plants with high cup quality, disease resistance, climate resilience, and other desirable traits—all without the need to turn to genetic modification. Historically, the combination of good yield, disease resistance, and high cup quality were difficult to achieve through traditional breeding. That is changing with the advent of F1 hybrids and molecular breeding.

**F1 hybrids.** F1 hybrids are new varieties made of the offspring of first generation (thus “F1”) crosses between genetically distinct Arabica parents (for example, a wild Ethiopian variety x Caturra). F1 hybrids are notable because they tend to have significantly higher production than non-hybrids, while maintaining high cup quality and disease resistance. Currently F1 hybrids can only be reproduced on a large scale in tissue culture laboratories (essentially, cloning a

Continued on p. 28



The F1 hybrid variety Centroamericano in a tissue culture lab. Source: World Coffee Research



Fully grown F1 hybrid Centroamericano on a farm in Guatemala. Source: David Laughlin

plant from itself using leaf tissue and growth hormones), which means they are more expensive to produce and relatively hard for farmers to access. A major breakthrough was made in 2016 that points to a future in which F1 hybrids may be able to be propagated via seed. If the technique can be replicated for other F1 hybrids, it would dramatically decrease the costs of hybrids and increase their availability for farmers around the world.

**Molecular breeding.** Breeders of tomatoes, onions, rice and other crops—but not coffee—have seen their worlds transformed by the recent advent of molecular breeding. An article in *Scientific American* describes the approach: “These modern plant breeders are not genetic engineers. Rather, they sequence the genomes of many different kinds of plants to build databases that link various versions of genes—known as alleles—to distinct traits. Then, they peek inside juvenile plants to examine the alleles that are already there before choosing which ones to grow in the field and how best to mate one plant with another... saving them a great deal of time and labor.”

In traditional breeding, you need a lot of space and time to observe how varieties perform in the field. Molecular breeding allows breeders to select high-performing varieties in the nursery (by genotyping the leaves of baby plants then discarding the trees not carrying the best genes) rather than waiting to observe the plant’s full three-year growth cycle. In this way, breeding becomes far more efficient. World Coffee Research is incorporating molecular approaches into its breeding program, with a particular focus on looking for DNA markers involved in coffee leaf rust resistance, vigor and yield, male sterility (useful for creating F1 hybrids by seed), and cup quality.



**To learn more about varieties visit:**  
[varieties.worldcoffeeresearch.org](http://varieties.worldcoffeeresearch.org)

# Coffee Leaf Rust in Central America

## *Preventing the next epidemic*

Since 2013, World Coffee Research has been working on a multipronged program to monitor, control, and prevent the devastating effects of coffee leaf rust in Central America with major funding from USAID, and partners including Texas A&M University, PROMECAFE, CATIE, CIRAD, and private industry.

The most urgent need for addressing coffee leaf rust is getting better information out to farmers about what varieties to plant, and effective practices for preventing and managing rust. Long-term needs include the creation of new rust resistant varieties, establishing an early warning system for disease epidemics, and establishing a professional seed sector to ensure that farmers have access to healthy, high quality plants.



Well-controlled rust. If properly cared for, coffee leaf rust can be present on plants without causing major problems with yields or quality. Source: Tim Willems



Poorly controlled rust. When rust is not controlled, it can lead to total defoliation and premature drying of cherries, with major losses to production and quality. Source: Tim Willems

## Taking the pulse of rust in 2016

- 18.2 million bags of coffee worth \$2.5 billion were lost to coffee leaf rust between 2011/2012 and 2015/2016.
- 1.7 million people in the region were put out of work.
- By 2016, the incidence of rust in most countries in the region had declined to under 15%. But in Mexico, El Salvador, and Guatemala, incidence was still as high as 60% in some regions.
- New research shows that resistance to coffee leaf rust is breaking down in some rust-resistant varieties developed in the 1950s–90s, meaning new sources of resistance must quickly be found. (To read more about WCR's efforts to create new rust-resistant varieties, see page 22.) Simultaneously, the world's only facility for testing rust resistance, CIFC in Portugal, has been significantly weakened by lack of funds. There is currently nowhere in the world that varieties can be screened for rust.

Source: Cumbre de Roya II, hosted by Anacafe in Guatemala City in February 2016. Presentations available online at: <https://www.anacafe.org/glifos/index.php?title=13NOT:II-cumbre-de-roya>

## Essential new tools for fighting rust

- Publication of *Prevención y Control de la Roya del Café*, a new guide for agronomists and technicians on the management and control of rust (see p. 14). A simplified version of the guide for farmers will be published in 2017. Free online at [worldcoffeeresearch.org/roya-manual](http://worldcoffeeresearch.org/roya-manual)
- Publication of *Coffee Varieties of Mesoamerica and the Caribbean*, a tool to help farmers determine the best rust-resistant varieties to plant (see p. 13). Free online at [varieties.worldcoffeeresearch.org](http://varieties.worldcoffeeresearch.org)
- Launch of WCR Verified, a coffee seed and nursery certification program that uses DNA fingerprinting so farmers can be certain the varieties they are buying are rust-resistant and healthy (see p. 45). Information at [varieties.worldcoffeeresearch.org/info/coffee/obtaining-plants](http://varieties.worldcoffeeresearch.org/info/coffee/obtaining-plants)

*These projects and those described below were made possible by the generous support of the American people through the United States Agency for International Development (USAID).*



Farmers in Yepocapa, receiving rust-resistant seedlings. Source: Paco Anzueto

## Helping smallholders in Yepocapa, Guatemala

In 2015, with funding from the Starbucks Foundation, WCR began a project to assist smallholder farming communities in Yepocapa, which had been devastated by the rust epidemic because producers had outdated, rust-susceptible trees. Farmers were provided with a new F1 hybrid variety called Centroamericano, which is resistant to rust with good cup quality. WCR is measuring how the new varieties are impacting farmer livelihoods—examining how they impact productivity, labor and input costs, and, ultimately, family outcomes—as well as the barriers to success.

**179** producers in 3 coops  
received plants in 2016

**131,253** trees distributed  
to farmers

## Biological control of coffee leaf rust

Costly fungicides and pesticides aren't the only way to control pests and diseases on a farm. Nature has developed complex and effective ways of reducing damage by pests and diseases. Every organism has a range of natural enemies—competitors, parasites or predators—that are capable of reducing the size of its population. In the wild, even coffee leaf rust has these natural antagonists. Two types of fungi are known to be particularly

important for coffee leaf rust in both natural and crop settings. Mycoparasitic fungi are fungi that “eat” other fungi (see photo below). Endophytic fungi live inside the tissue of host plants and work as bodyguards, protecting the plant against attacks by pathogens and pests. Both types of beneficial fungi might be exploited on coffee farms as organic control products or sustainable tools for coffee leaf rust management. World Coffee Research is working with Robert Barreto and Harry Evans at Universidade Federal de Viçosa in Brazil to identify and evaluate such fungi to be used in the fight against coffee leaf rust. In 2017, World Coffee Research will be evaluating the most promising candidates in Brazil and, later, at the WCR Research Farm in El Salvador.

**1216** fungi that live in association with coffee rust were collected from farms and forests worldwide

In the lab, **31** fungi showed promise in inhibiting rust

**4** fungi were highly promising and will be tested in the field



A *C. canephora* leaf has been infected by *Hemileia coffeicola* rust (pale yellow). But a mycoparasitic fungi (*Paranectriella* sp.; grey) has attacked the rust and left only few healthy rust pustules remaining. Source: Harry C. Evans



## How does coffee leaf rust affect flavor?

The ideal coffee variety would be one that is disease resistant, high quality, and high yielding. But that combination isn't always easy to achieve. In order for coffee breeders to produce this trifecta, they need to understand the relationships between disease, flavor and yield.

In this trial, Ph.D. student Fabián Echeverría Beirute subjected 320 plants of two varieties (half Red Catuai, susceptible to leaf rust; half H3, a rust-tolerant F1 hybrid) to different levels of stress caused by disease and high fruit load. He left some plants with 100% of their cherries and thinned some to 50%. He sprayed half the plants to control leaf rust, and left the others alone. Then, he evaluated how the different varieties were affected by rust, and how rust levels in turn affected yield, cherry chemistry, and flavor/aroma.

**8 treatments: 2 varieties x 2 fruit loads x 2 rust controls**

**5 of 60 flavors and aromas were significantly different**

Preliminary results in 2016 confirm that some aroma and flavor attributes were different depending on variety, fruit load and disease level. Beverage sensory analysis using the World Coffee Research Sensory Lexicon revealed that 5 of 60 attributes were significantly different between the thinning and rust control treatments and between varieties. Profiles of the chemical volatile compounds were also changed. Of 154 chemical volatile compounds detected, 13 were differently expressed in the Catuai and 9 in H3; 5 of the compounds were significant for both varieties. In 2017, we expect to complete the molecular analysis of fruit and leaf samples, and will use them to look for interactions between plant health, metabolic pathways, and gene expression involved in plant performance or cup quality. Echeverría's research will help determine whether there is a method for understanding how a plant's health affects performance and cup quality, and to use this information when developing new coffee varieties.

## How does shade interact with rust epidemics?

Some researchers have found that shade helps protect coffee from leaf rust, and others have found that it doesn't. Still others have found that the kind of shade matters. So what is the truth?



Some types of shade may have undesirable impacts on coffee leaf rust, despite being an important practice for coffee growers amid rising global temperatures. Source: Leo Lombardini

Recently, researchers from CIRAD and CATIE have developed a new research approach to study the effects of shade on coffee rust. To understand the impact of shade, they are looking at how shade interacts with different phases of the life cycle of the tiny fungi.

In 2016, rust expert Jacque Avelino conducted a study at CATIE in Turrialba, Costa Rica comparing full sun exposure and shade provided by the Cashá tree. Avelino and his team—including two students who successfully earned their master’s degrees working on the project—found that Cashá shade has mostly undesirable effects on coffee rust. Coffee plants in Cashá shade had on average 43% more rust spores than trees in full sun. Shade appears to help leaf rust infect and penetrate into the coffee leaf, and helps disperse fungal spores when it’s raining (shade increases the kinetic energy of raindrops; when it’s dry, shade stops wind from carrying spores as far and therefore inhibits dispersal). In short, full sun appears to help rust “wash out” of coffee foliage and fall to the ground, disrupting the disease’s life cycle. But all shade is not equal. There is some indication that small, manageable shade trees with flexible, lobbed leaves (enabling high shade cover in the dry season and low shade cover during the rainy season)— are better for controlling rust. Given the essential role of agroforestry in mitigating climate change, different shade types should be explored in the future research. Final results will be published in 2017.

Given the importance of agroforestry for climate change adaptation and smallholder farmers, it is essential to determine shade types better for controlling rust

## Did climate change cause the leaf rust epidemic?

Coffee researchers agree that there was more than one factor that led to the rust epidemics in Colombia in 2008 and Central America in 2012, but there is generally a consensus that climate factors were an important contributor.

A key 2015 paper in the journal *Food Security* concluded that drivers of coffee leaf rust epidemics had primarily to do with low coffee prices and the weather. “When farmers’ difficult economic situations are combined with meteorological conditions favourable to coffee rust development, the result is a very intense epidemic.” The authors make the following points:

- “Meteorological anomalies were crucial to the epidemic’s development.” The rainy season started earlier than normal in 2012 in Central America, probably inducing the onset of an early coffee rust epidemic. Also critical was an increased number of days when temperatures fell into the optimal range for coffee rust to develop, shortening the latency period for the disease.
- The authors call Central American coffee rust epidemics “economic epidemics.” Researchers show that every severe epidemic in the last 38 years was concurrent with “low or even negative coffee profitability periods.” They found that coffee farmers generally know how to fight rust, but didn’t use good control methods during epidemics because of low prices and reduced support from government extension programs.
- Coffee trees across the region were too old (over 30 years on average), and most farmers didn’t have rust-resistant cultivars planted.

The authors conclude that disease epidemics are likely to get worse in the future, not better. They point out that that “weather conditions experienced in Central America in 2012 and Colombia in 2008 share some common characteristics with climate change forecasts.” They conclude that recent coffee rust epidemics should be **“considered as a warning for the future.”**

Source: Avelino et al (2015). The coffee rust crises in Colombia and Central America (2008–2013): impacts, plausible causes and proposed solutions. *Food Security* (7): 303-321. DOI 10.1007/s12571-015-0446-9



A coffee producer in Guatemala inspects his plants for rust. Source: Devin Barker

## **The future of rust**

Though many of the worst rust-affected countries in Central America are showing signs of recovery from the rust epidemic, there remains much work to be done. In 2017, World Coffee Research will continue working with USAID and partners to breed the next generation of rust-resistant varieties, to identify new resistance pathways, to explore novel approaches like biological control, to assist farmers in accessing better information and healthier plants, and to understand the optimal shade structure to minimize coffee leaf rust.

# Preparing for Climate Change

## Coffee's biggest long-term threat

Climate change severely threatens the long-term sustainability of coffee as a global commodity crop. Research has demonstrated that rising temperatures, increasing weather volatility, and increased prevalence of diseases and pests associated with climate change contribute to both lower yields and lower quality coffee for producers—with following impacts on their livelihoods. Severe weather shocks like prolonged drought, especially when combined with poverty, force farmers out of coffee altogether and contribute to human migration.



By 2050, we need to **double** world production, but suitable land will decline by **half**.

World Coffee Research is working with global partners to conduct advanced research into the impacts of climate change on coffee and create research-based solutions for farmers. We are working to answer questions including:

- Which coffee production areas are most vulnerable, and which are most likely to be able to successfully adapt to a future climate?
- Which coffee varieties are best adapted for weather extremes such as drought and high temperatures? How does plant nutrition affect resilience?
- What conditions are most/least favorable for the spread of coffee diseases and pests?
- What are the key constraints that different kinds of farmers face in adopting new technologies and practices that ensure climate resilience?

## Four key impacts of climate change on coffee

1. There is strong evidence that rising temperatures and altered rainfall patterns are already affecting coffee yields, quality, pests, and diseases—badly affecting the **economic security** of farmers in some coffee regions.
2. According to research conducted by CIAT and World Coffee Research, without action the global area suitable for coffee production will **decline by 50 percent by 2050**, at the same time as demand is expected to double.
3. By 2080, wild Arabica, an important genetic resource for breeders and farmers, is expected to become **extinct**, if deforestation doesn't destroy it sooner.
4. Unlike most agricultural commodity farmers, coffee producers are mostly smallholders who have little capacity to adapt to a more volatile and hotter world, making them especially vulnerable to **abandoning coffee production**.

For overviews of recent research on coffee and climate, consult the following reports:

- The Climate Institute. 2016. *A brewing storm: The climate change risks to coffee*. Available at: [www.climateinstitute.org.au/coffee.html](http://www.climateinstitute.org.au/coffee.html)
- Earth Insitute. 2015. *The impacts of climate change on coffee: Trouble brewing*. Available at: [eicoffee.net](http://eicoffee.net)

## Guiding climate change adaptation

Everyone is talking about helping farmers adapt to a changing climate. But how do you do it? Without an understanding of what the impacts are expected to be, it's impossible to plan effectively for the future.

For CIAT and World Coffee Research, Dr. Christian Bunn is working to map coffee production zones that are expected to remain suitable for coffee by 2050 with small adaptations (“incremental” practices like improving shade and soil management), with larger adaptations (“systemic” changes like planting better varieties or switching to Robusta), as well as areas where adaptation appears unfeasible and farmers would be

better off “transforming”—switching to other crops. This research builds on prior work demonstrating that if the coffee sector does nothing, 50% of land currently suitable for growing coffee will become unsuitable by 2050.

Dr. Bunn is working to identify which future climate scenarios and characteristics will determine whether a farmer will likely be able to adapt incrementally or systemically, and which will be required to “transform” (Figure 1). Spatial analogs—places that today have climates similar to those predicted for the future—will further support agronomists to shape the production systems of tomorrow.

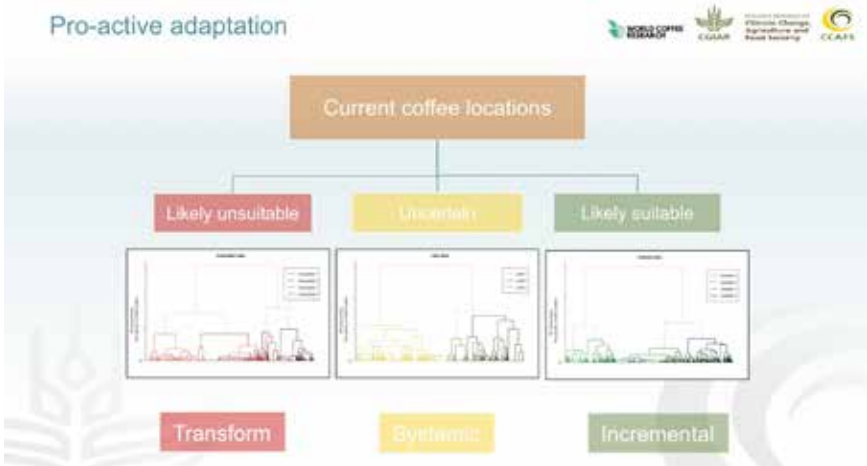


Figure 1. A model for identifying whether producers in a region can adapt incrementally, systemically, or must transform their livelihoods, based on current and future predicted agroecological zones.

## The future of coffee and climate research

**Tools for climate-smart agriculture.** World Coffee Research will redouble our efforts on climate change in 2017 through participation in a collaborative effort, funded by USAID, to build and pilot new tools to assist coffee companies in adopting climate-smart agriculture practices. The effort brings together a consortium of research institutes, nonprofits, and coffee experts including Coffee & Climate (c&c), Conservation International, Root Capital, the Sustainable Food Lab, and the Climate Change, Agriculture, and Food Security (CCAFS) program of the Consultative Group on International Agricultural Research (CGIAR).



Breeding for agroforestry shade environments will be a key focus for WCR in the coming decade. Source: Hanna Neuschwander

**Breeding for climate change.** The creation of new coffee varieties better adapted to climate change is critical for the future of coffee. In 2017, WCR will join a major effort funded by the EU to address the challenges posed by climate change through coffee breeding. One of the key strategies identified for climate resilience in coffee is agroforestry—growing coffee under shade. A consortium of research institutions will work to understand how and why different varieties are more climate-resilient and appropriate for smallholder farmers working in agroforestry systems. The project will demonstrate how breeding programs can benefit both smallholder farmers by increasing their incomes and resilience, and the coffee industry by providing higher amounts of high quality coffees. Combining extensive phenotyping with advanced DNA analysis on a scale that has not previously been undertaken with perennial tree crops, BREEDCAFS (Breeding Coffee for AgroForestry Systems) will lead to an unprecedented understanding of coffee physiology.

20 partners in 20 countries

New varieties for agroforestry and climate resilience



## Genetic Resources Conservation

*Preserving the world's most important coffees, forever*



Sarada Krishnan, second from the left, leads a visit to the FOFIFA germplasm station at Kianjavato in Madagascar. Source: Sarada Krishnan.

A germplasm collection is a “bank” for coffee’s genetic diversity—typically fields of different cultivated and wild species of coffee—that can be drawn upon by coffee researchers to solve current or future problems facing the crop. Coffee breeders turn to genebank collections to find novel traits to address challenges like rising temperatures, drought, and pests and diseases.

Unfortunately, most of the main genebanks for coffee are in disrepair. **Losses in these collections of coffee’s genetic resources severely threaten the future of the crop.**

There are over **50** genebanks in the world that contain plants in the *Coffea* family—**half** hold significant collections

In 2016, World Coffee Research and the Global Crop Diversity Trust conducted an extensive survey of 31 coffee genebanks and conducted site visits to eight collections to map the scope of the problem. The results of the survey and site visits indicate that the world’s coffee collections are under threat and not widely used.

## Genebank survey results

1. Coffee genebanks are highly insecure in their funding and land tenure, putting some collections at risk of disappearing altogether.
2. Coffee genebanks are not safely duplicated, meaning there is high risk of losing key genetic resources forever.
3. Coffee genebanks have very limited access and exchange of material, even within institutions in the same country, meaning the resources that exist are not being used. Only 1% of the plants are used by researchers and breeders outside the host country each year.
4. Coffee genebanks severely lack information systems—none make information about their collections easily accessible (e.g., searchable online), making it virtually impossible for researchers and breeders to make use of novel genetic resources.
5. Coffee genebanks fluctuate in management (e.g., weeding, pruning, rejuvenations, fertilization, and replanting), making plants vulnerable to disease and death.

In 2017, WCR and Crop Trust will release a plan for the strategic conservation of global coffee genetic resources

## A strategy to save coffee

Genetic resource conservation is essential for a sustainable future of coffee and coffee farmers. In 2017, WCR and Crop Trust will release a plan for the strategic conservation of global coffee genetic resources, including a call to action for industry partners to fund the effort.

Key institutions including the International Coffee Organization (ICO), InterAfrican Coffee Organisation (IACO), and Specialty Coffee Association (SCA) have endorsed the creation of such a strategy.

An unidentified coffee species found in Madagascar. Source: Sarada Krishnan



# International Multilocation Variety Trial

*An unprecedented global exchange of the world's highest quality coffee varieties*



Winner of the 2016 SCAA Sustainability Award

Countries participating in the International Multilocation Variety Trial (IMLVT) receive 35 of the world's top-performing coffee varieties to grow and evaluate in standardized research field plots maintained by the country's national coffee or agricultural research organization. Before being sent to the countries, seedlings are replicated in sterile in-vitro cultures at a phytosanitary lab in Florida to ensure they are completely disease-free. Most of the varieties have never been tested on a broad basis.

Twenty three countries—including four new countries in 2016—are participating in the trial. Once plants are in the ground, each country evaluates how the different varieties perform—studying the *genetics x environment* interaction. In addition, the network of test sites around the world serves as a platform to monitor disease movement and levels, interaction between environmental factors and quality, and climate trends.

On each plot, an exhaustive list of variables about the plot and the performance of each plant is measured—including plant vigor, productivity, disease and pest incidence, bean characteristics, bean chemistry, and final cup quality. Each country can monitor how the different varieties perform under local conditions. The best-performing varieties can then be selected, multiplied and distributed to producers to increase supplies of quality coffee for those countries.



Plants were established in a nursery at Anacafe in Guatemala, one of 24 participating countries, before being transferred to the field. Source: Leo Lombardini

Each country tests **35** of the world's best varieties

**4** new countries in 2016: Australia, Rwanda, United States, Zimbabwe

**17** of **24** countries have received seedlings

**13** countries have plants in the field

## IMLVT timeline

- **2012–2014** Protocol design, country recruitment, obtaining permission to use varieties from 14 countries/breeders/suppliers
- **2014–2015** Multiplication of varieties in sterile phytosanitary lab in Florida, distribution of in vitro plants to countries
- **2015–2016** In vitro plants received by participating countries, grown out in nurseries, first trial sites planted at country experimental stations
- **2017–2018** First evaluations of plant performance will be taken. New countries added.
- **2050** The trial is expected to continue indefinitely—for 30–40 years—to evaluate how the plants perform over time and under changing climate conditions.

## WCR Verified Plants

*The world's first coffee seedling quality assurance program to ensure healthy, genetically pure plants*



In addition to soil, every farmer's most important asset is his or her plants. Walk into any neighborhood nursery in the US or EU and you will find shelves lined with vegetable and flower seed packets, guaranteed through certification schemes to be healthy and genetically pure. That means you can put the seed in the ground and expect it to grow as described on the label.

Coffee producers have no such guarantees. Are the plants labeled "roya-resistant" really resistant to coffee leaf rust? Are those geishas really geishas? Are the plants free of bent roots or nematodes? Ensuring access to high quality plants is critical to lowering the risks farmers face and to improving productivity and quality.

World Coffee Research Verified is the first sector-wide program to verify coffee plant quality and variety, using new DNA fingerprinting technology. Through a partnership forged in 2016 with third-party certifier NSF, the program will expand in 2017 to Guatemala, Nicaragua, and Costa Rica, and to all areas of the coffee producing world in the coming decade.

## Nurseries are Verified based on four pillars:



### **Nursery Standards**

The nursery follows best practices for raising healthy, disease-free plants. 11 critical points evaluated.



### **Genetic Purity**

The coffee variety has been identified using World Coffee Research DNA fingerprinting so farmers can be certain they are buying the correct variety.



### **Education**

The nursery makes information about the agronomic performance of different varieties (such as the *Coffee Varieties of Mesoamerica and the Caribbean* catalog) available to farmers so they can make an informed choice.



### **Breeder's Rights**

The nursery gives credit to breeders and their rights are respected.



Healthy coffee plants at a nursery in Nicaragua. Source: World Coffee Research



A coffee plant's roots are infected with *M.exigua* root knot nematodes. The Verified program ensures healthy plants. Source: Tim Willems

In 2016, **3** nurseries were  
Verified in a pilot study

Each nursery evaluated on **4**  
pillars and **11** critical points

### **Verified nurseries (2016 pilot study)**

- El Salvador: Las Tres Puertas nursery (J.Hill y Cia.) verified for Marsellesa variety
- Nicaragua: La Cumplida nursery (Exportadora Atlantic S.A./ECOM) verified for Marsellesa and Centroamericano varieties
- Guatemala: Pilones de Antigua verified for Centroamericano variety

**Verified nurseries directory online at:**  
[varieties.worldcoffeeresearch.org/nurseries](https://varieties.worldcoffeeresearch.org/nurseries)





## Flor Amarilla Farm

*The latest from WCR's research farm in Santa Ana, El Salvador*



The World Coffee Research team at the WCR farm in October 2016. Source: Salvador Urrutia Loucel.

The Flor Amarilla experimental farm was established in 2015, and is used for field trials of coffees varieties, plant nutrition and other farm technology performance.

**7 hectares, 950 MASL, 3 active trials**

**The WCR Core Collection.** The Flor Amarilla farm contains the full WCR Core Collection, the most diverse collection of plant material ever assembled for global coffee breeding. The collection is mostly comprised of Arabica landraces that have never been used in breeding before. In 2016, plants went into the field and the first observations of growth were taken. Characterizing the varieties' physiological performance and cup quality will be essential to future research that makes use of the collection. For more about the Core Collection, see p. 23.

**97 genetically diverse Arabicas, 2,073 plants**

**Experimental F1 hybrids.** In 2016, we established a plot of new WCR F1 hybrid varieties (see p. 22). At Flor Amarilla, these varieties will be evaluated for quality, yield, coffee leaf

rust resistance, and drought tolerance in the coming years. The best varieties will be released for farmers in Central America by 2023.

## 46 experimental varieties, 527 total plants in the field

**Soil treatments.** A plot of seven different commercial varieties is planted in a random block design (Red Bourbon, Orange Bourbon, Kenya, Costa Rica 95, Marsellesa, Icatú Amarillo, Castillo). In 2017, the plot will be used to test organic soil treatments including mycorrhizal fungi and biochar.

## 7 varieties, 50 plants per variety, 1,750 plants

**Three new trials in 2017.** In 2017 three new trials will be established at the farm, including a demonstration plot for our Global Coffee Monitoring Program (see p. 17), a plot for the International Multilocation Variety Trial (see p. 43), and tests of root-stock grafting practices and their effectiveness for improving drought tolerance and climate resilience.

## A new regional headquarters office in El Salvador

A Central American regional headquarters office was established in October 2016 through the support of longtime WCR supporter J.Hill y Cia S.A. de C.V. The office will coordinate World Coffee Research's projects in the region, including a Central American coffee breeding program, a program to verify that coffee nurseries are producing healthy, genetically pure plants, and a program to install a network of on-farm trials of improved coffee varieties. The office is located approximately 10 miles from the WCR Research Farm at the Tres Puertas complex.

WCR is proud to have operations in El Salvador, which was hit especially hard by the coffee leaf rust epidemic that began in 2012 and is in the midst of a three-year drought. The country was once a leading producer of coffee, but production has fallen dramatically.

### Traveling to El Salvador?

Visit the WCR Farm to see the work we do—

contact [info@worldcoffeeresearch.org](mailto:info@worldcoffeeresearch.org)

# Kahawara Bora Ya Kivu

## *Revitalizing coffee in a war-torn region*

In the 1970s and 80s, the Lake Kivu region at the border of Democratic Republic of Congo (DRC) and Rwanda was one of Africa's leading exporters of coffee. But a wave of violence that began in the 1990s, coupled with poverty and disease, has claimed the lives of over 5 million people and destroyed much of the country's coffee market. Despite the odds, 4,000 smallholders in the region have continued producing coffee.

Since 2012, WCR has supported a \$6 million project to revitalize the once-great coffee region. The project is led by Catholic Relief Services (CRS) and funded by USAID and the Howard Buffet Foundation. To restore the coffee sector in Kivu, WCR provided scientific and agronomic support to understand the main constraints to productivity and quality. The project ended in December 2016.

### **Key findings**

A profitability analysis by WCR showed that of five main farming approaches (including growing coffee alone, and intercropping with various legumes), only farmers who were intercropping with groundnuts were making a profit—on average, 5% per year.

### **Most coffee farmers in Kivu are losing money by growing coffee**

The following are the primary factors we identified for farmers' lack of profitability:

- Soils are severely depleted. This, mixed, with a cultural habit against using fertilizers, severely limits the production and profitability of coffee farming in the region.
- In Kivu, farmers typically intercrop with beans. Local farmers practice a unique style of manual hoeing of the soil, which requires double the labor (300 days of labor instead of 150), degrades already degraded soils, and damages the surface roots of coffee trees.
- Farmers don't have access to good varieties. Local varieties produce good cup quality but are very low yielding. In 2016, WCR succeeded in bringing 26 of the world's top varieties to Kivu via the International Multilocation Variety Trial. They will be evaluated in coming years and the best may eventually be made available to DRC farmers.

## Using advanced genotyping tools to identify the coffee varieties of Kivu

World Coffee Research undertook an evaluation of coffee varieties available for farmers in the Kivu region, using multivariate analyses from molecular markers to determine the identity of available varieties.

Most varieties available to farmers in the region were selected at Congo's coffee research station, INERA, or at the Rwanda Research Institute in the 1960s and 1970s. Farmers have also indentified interesting local populations that they search out for new plantings.

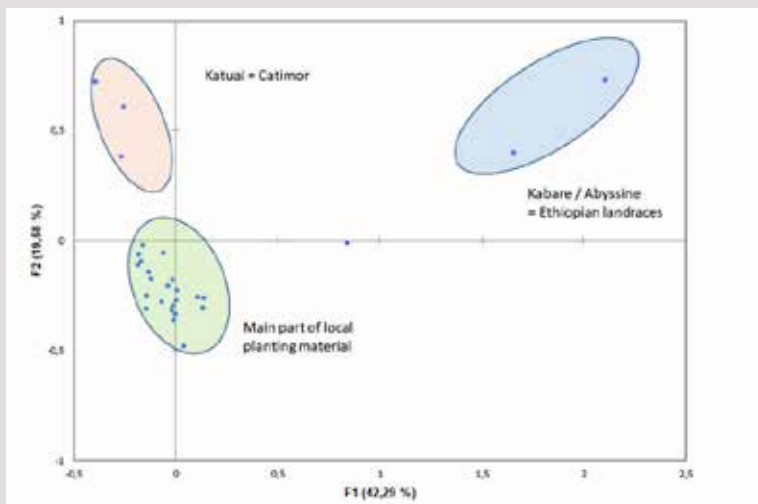


Figure 1. Kivu varieties, grouped according to genetic similarity.

**Orange:** “Katuai.” Katuai was introduced without control from Rwanda. While it sounds phonetically like the Brazilian Catuai and locals were under the impression that it was the same high-quality cultivar, genetic analysis revealed that it is in fact a low-quality, leaf-rust-resistant Catimor variety, most likely introduced from Portugal into Rwanda in the 90s. With this new information, INERA can make more informed recommendations for DRC farmers, including discouraging the use of low-quality varieties.

**Blue:** Kabare and Abyssinie are derived from Ethiopian landraces and were introduced locally by INERA.

**Green:** A group of traditional Bourbon- and Typica-related varieties. Interestingly, most plants found on local farm nurseries were from this group. It appears that even though there is wide diversity available to farmers in DRC, including Ethiopian-derived varieties (see blue above), they prefer Bourbon-like varieties because they are more vigorous. Highlights from this group include:

- **Bourbon-derived varieties**, including **Rwandese BM** and **Jackson**. Farmer-selected varieties **Kahunda** and **Chizungu** were closely related to Bourbon (in fact, Chizungu was identical) and were the favorites of locals.
- **“BMJ”** Locals call this tree BMJ, but our analysis confirmed that the trees are genetically distinct from Blue Mountain Jamaica (synonymous with Typica).
- **Mulungu** Originated from a controlled cross between genetically distant parents in the 1960s
- **Typica**
- **Harrar**

These results of an analysis of Kivu varieties (see box) indicate that planting material available to farmers has high genetic diversity compared with, for example, Central America, but that it is not well organized or clearly differentiated. The varieties available are all older, rust-susceptible, and lower yielding. Three Bourbon-related varieties from neighboring Rwanda—BM71, BM139 and Jackson—were growing better than local Congolese varieties. Of Congolese varieties, only Harrar performed adequately. All available varieties are susceptible to coffee leaf rust, although so far the disease is not a major concern in the area. Despite some having high cup quality potential, farmers are not fully realizing that potential with current agronomic and processing practices.

In 2017, WCR hopes to continue working with partners to revitalize the region through improving the availability of high quality varieties, promoting better agronomic practices (such as alternatives to manual hoeing), and making links with specialty coffee buyers.

The future of coffee  
is in your hands.



**WORLD  
COFFEE  
RESEARCH™**



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# YOU'RE INVITED!

@ Global Specialty Coffee Expo, Seattle

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## **Member's General Assembly Friday, April 21, 2:00–3:30pm**

The annual gathering of WCR member companies, scientists, staff, partners and other stakeholders to discuss recent research progress, review organizational finances and strategic direction, and give input on future research. Members provide feedback and direction to WCR's board and staff, ask questions, and meet other members.

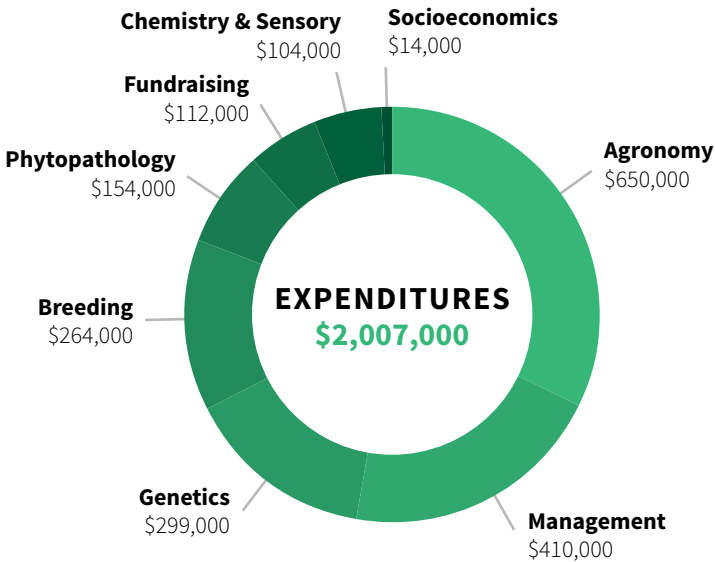
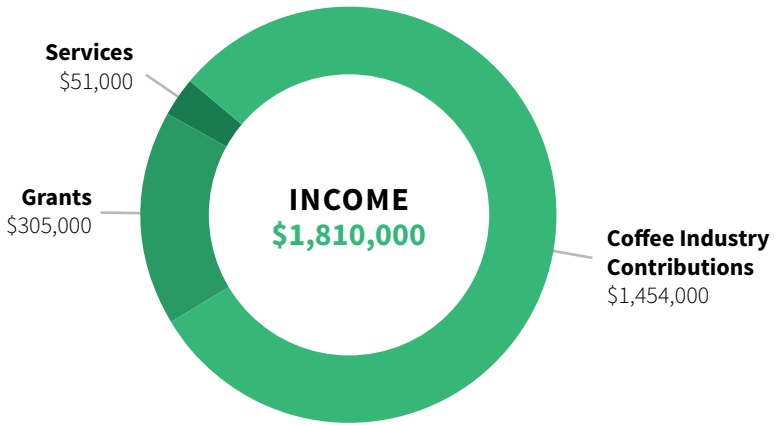
RSVP to [info@worldcoffeeresearch.org](mailto:info@worldcoffeeresearch.org).

## **Think + Drink Happy Hour Friday, April 21, 4–5pm**

Hear the latest in coffee research, learn about WCR's Checkoff Program, and meet our scientists, staff, and board.

All are welcome, no RSVP required.

# 2016 FINANCES



## 2016 YEAR-END FINANCIAL POSITION

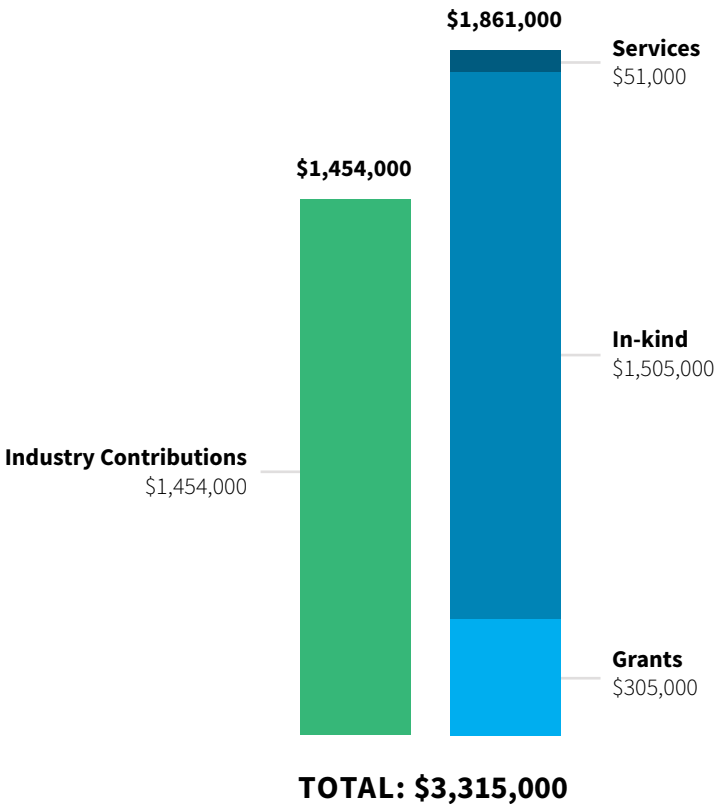
**Cash:** \$1.675 million. **Other assets:** \$71,000. **Liabilities:** \$228,000.



# INVESTMENT IMPACT

By leveraging in-kind contributions from our partners, along with grant dollars, public funds, and service income, we are able to **double** the impact of the coffee industry's investment in our work.

For every **dollar** contributed by donors in the coffee industry, WCR conducts **\$2** worth of research.



# TEAM

Our core scientific and administrative team apply their expertise in coffee, genetics, plant science and diseases, and sensory science to create and execute an ambitious research agenda.

In 2016, WCR's team grew to **13**

- Tim Schilling, *CEO*
- Christophe Montagnon, *Scientific Director*
- Hanna Neuschwander, *Communications Director*
- Siaska Castro, *Administration and Finance Director*
- Nicole Atwell, *Financial Accountant*
- Salvador Urrutia Loucel, *WCR Central American Representative*
- Francisco Anzueto, *Scientific Coordinator for Central America*
- Mark Smith, *Coffee Rust Project Director*
- Sara Bogantes, *Global Coffee Monitoring Program Regional Coordinator*
- Benoit Bertrand, *Coffee Breeder*
- Trish Klein, *Molecular Geneticist*
- Iris Romero Gonzales, *WCR Farm Manager*
- Daniel Dubon, *Data Manager*

## COLLABORATING RESEARCHERS AND STUDENTS

Researchers and graduate students from around the world are working on problems and projects identified as essential by World Coffee Research core scientific staff.

- Jacques Avelino, *CIRAD French Agricultural Research Center for International Development*
- Bárbara Castanheira Ferrara Barbosa, *postdoctoral fellow, Horticultural Sciences, Texas A&M University*
- Roberto Barreto, *Univerisdade Federal de Viçosa, Brazil*
- Fabián Echeverría Beirute, *Ph.D. student, Soil and Crop Sciences, Texas A&M University*
- Taya Brown, *Ph.D. student, Horticultural Sciences, Texas A&M University*
- Christian Bunn, *CIAT International Center for Tropical Agriculture*
- Carlos Carvalho, *EMBRAPA, Brazil*
- Harry Evans, *Univerisdade Federal de Viçosa, Brazil*

- Lauren Fedenia, *Ph.D. student, Horticultural Sciences, Texas A&M University*
- John Karuru, *Rwanda*
- Chris Kerth, *Agriculture & Life Sciences, Texas A&M University*
- Joseph Kimemia, *Kenya*
- Sarada Krishnan, *Denver Botanical Gardens, Denver*
- Christian Mas, *INERA, Democratic Republic of Congo*
- Elias de Melo, *CATIE Tropical Agricultural Research and Higher Education Center, Costa Rica*
- Rhonda Miller, *Professor, Agriculture & Life Sciences, Texas A&M University*
- Beatriz Moreno, *Anacafe, Guatemala*
- Elmer Roldan Salazar, *Ph.D. student, Horticultural Sciences, Texas A&M University*
- William Solano, *CATIE Tropical Agricultural Research and Higher Education Center, Costa Rica*
- Paul Songer, *Songer & Associates*
- Alfredo Zamarripa, *INIFAP Mexico*

## BOARD OF DIRECTORS

Our board members are some of the most important leaders and thinkers from coffee companies around the world. They work hard behind the scenes to guide our programs.

- Brett Smith, *Counter Culture Coffee (Chair)*
- Tracy Ging, *S&D Coffee and Tea, Inc. (Vice Chair and Secretary)*
- Shawn Hamilton, *Java City (Treasurer)*
- Ric Rhinehart, *Specialty Coffee Association of America*
- Lindsey Bolger, *Keurig Green Mountain Coffee*
- Mike Keown, *Farmer Brothers*
- Furio Suggi Liverani, *illycaffè*
- Tanya Lomax, *Mars Drinks (outgoing)*
- Carlos Lopez, *S&D Coffee and Tea (outgoing)*
- James McLaughlin, *Intelligentsia Coffee and Tea*
- Ben Pitts, *Royal Cup Coffee (outgoing)*
- Eric Ponçon, *ECOM Group (incoming)*
- Ed Price, *Center on Conflict and Development*
- Matt Saurage, *Community Coffee Company*
- Marc Schonland, *Royal Cup (incoming)*
- Jim Trout, *The J. M. Smucker Company*
- Doug Welsh, *Peet's Coffee & Tea*

## MEMBERS

Our members—companies and organizations large and small—help set the global agenda for coffee research. Their support is the foundation for a vibrant and sustainable coffee sector.

In 2016, **71** coffee companies supported WCR’s work, an increase of **65%** over the prior year.

### Key supporters

- USAID
- Howard G. Buffet Foundation
- Starbucks Foundation
- Specialty Coffee Association of America (SCAA)

### Platinum Members



## Gold Members

- Allegro Coffee Company
- Community Coffee Company
- Counter Culture Coffee
- Datterra
- Foodbuy
- illycaffè
- Intelligentsia Coffee & Tea
- Java City
- Key Coffee
- Mercon Coffee Group
- OLAM Specialty Coffee
- Peet's Coffee & Tea
- Royal Cup Coffee
- S&D Coffee Roasters
- Taylors of Harrogate

## Silver Members

- 1 Lounge
- Arab Coffee Co., Inc.
- Atlas Coffee Importers
- Batdorf & Bronson Coffee Roasters
- Bridge Coffee
- Buckman Coffee Factory
- Cafe Fadie (Kyokuto Fadie Co., Ltd.)
- Camel Coffee Company
- Caravela
- C-COOP
- Coffee Nexus
- Coffee Review
- Crop to Cup
- Cuperus Koffie
- Dunn Brothers
- Equator Coffee and Tea
- Gaerock
- Gaviña Coffee
- Genius Coffee
- Hacienda La Minita
- Honey Coffee, Inc.
- InterAmerican Coffee
- Irving Farm Coffee Roasters
- Japan Roasters Network
- Kaldi's Coffee
- Kickapoo Coffee
- La Marzocco International, LLC
- Marigold Coffee
- Marubeni Foods Corporation
- Mr. Espresso
- NEAT Coffee
- Old City Coffee
- Orsir Coffee
- Pacific Espresso
- Philz
- Quaffle
- Reunion Island Coffee
- RGC Coffee
- Rose N Cranz Roasting Company
- Salt Spring Coffee
- Specialty Coffee Association of Japan
- Sweet Maria's Coffee
- Swiss Water Decaffeinated Coffee Company, Inc.
- Terarosa (Haksan Co. Ltd.)
- The Coffee Source
- Toa Coffee Co. Ltd.
- Tony's Coffee
- Union Hand-Roasted Coffee
- Vessel Coffee Roasters
- Walker Coffee Trading
- Wilbur Curtis

## PARTNERS

- ACO The African Coffee Organization/ Research and Development
- ACRN African Coffee Research Network
- AFCA Africa Fine Coffees Association
- APLU American Public Land Grant Colleges and Universities
- ANACAFE Guatemala National Coffee Association
- CABI Centre for Agricultural Bioscience International
- CATIE Tropical Agricultural Research and Higher Education Center, Costa Rica
- CIAT International Center for Tropical Agriculture, Colombia
- CIC Coffee Industry Corporation, Papua New Guinea
- CIRAD French Agricultural Research Centre for International Development
- CCRI Central Coffee Research Institute, India
- CRI Coffee Research Institute, Kenya
- CRI Coffee Research Institute, Zimbabwe
- Crop Trust, Germany
- DARS Department of Agricultural Research Services, Malawi
- Denver Botanic Garden
- EMBRAPA CAFÉ Brazilian Coffee Research Consortium
- ECOM Trading, Inc.
- Finca Aquiares, Costa Rica
- Fundação Aggie de El Salvador
- Global Coffee Review (WCR Media Partner)
- Hanns R. Neumann Stiftung, Germany
- HARC Hawaii Agriculture Research Center
- ICCRI Indonesian Coffee and Cocoa Research Institute
- IITA Agricultural Research for Development in Africa
- Indian Coffee Board Research and Development
- INECOL Institute of Ecology, Mexico
- INERA National Institute for Agricultural Research, Democratic Republic of Congo
- IRAD Institute for Agricultural Research for Development, Cameroon
- J.Hill & Cia, S.a. de C.V., El Salvador
- Junta Nacional de Peru
- KALRO Kenya Agricultural and Livestock Research Organization
- Kansas State University
- Ministry of Agriculture and Irrigation, Peru
- NAEB, National Agricultural Export Development Board, Rwanda
- Nicafrance, Nicaragua
- Norman Borlaug Institute for International Agriculture at Texas A&M University
- Northern Coffee Corporation Ltd., Zambia
- Peruvian National Coffee Board
- PROMECAFE – Regional Cooperative Program for the Technical Development and Modernization of Coffee Culture
- Royal Botanic Gardens, Kew
- RTC, Rwanda Trading Company
- San'a University, Yemen

- Starbucks Corporation & Finca Alsacia
- Southern Cross University, Australia
- Texas A&M University
- UCB Catholic University of Bukavu, Democratic Republic of Congo
- UFV Universidade Federal de Viçosa, Brazil
- USDA Coffee Research Program

## **AFFILIATED ORGANIZATIONS**

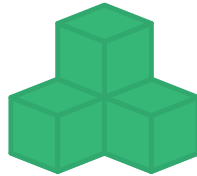
- ACE Alliance for Coffee Excellence
- CQI Coffee Quality Institute
- ICO International Coffee Organization
- NCA National Coffee Association
- SCAA Specialty Coffee Association of America
- SCAE Specialty Coffee Association of Europe
- SCAJ Specialty Coffee Association of Japan



# THE CHECKOFF PROGRAM



**URNS YOUR HALF PENNY**



**INTO \$3 MILLION IN RESEARCH**

Through the Check-Off program, roasters can support our work by contributing half a penny per pound (\$.005/lb.) or one cent Euro per kilo (€0.01/kg) of green coffee purchased through participating importers. See a list of participating importers online.

**Join us to ensure the future of coffee:  
[worldcoffeeresearch.org/checkoff](http://worldcoffeeresearch.org/checkoff)**

