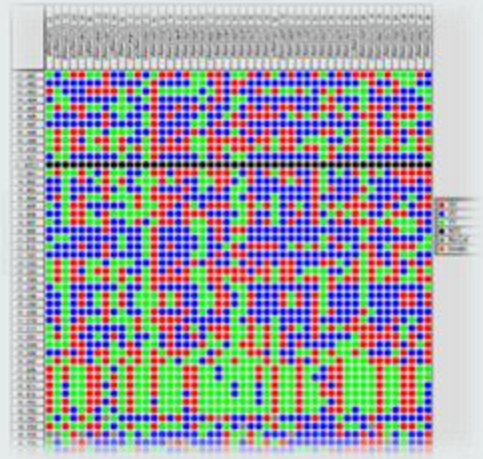
Coffee Leaf Rust Variety Trials in Hawaii

Tracie Matsumoto, USDA DKI PBARC

Overview

- Update on Coffee Germplasm
- Genotyping of Coffee and Importance
- International Multi-Location Variety Trial

National Plant Germplasm System - Coffee



SNP Genotyping
ARS Beltsville

Importation and Quarantine
of New Germplasm ARS Hilo

Primary Coffee Collection
ARS Hilo

Backup Coffee Collection
ARS Mayagüez

Long Term (Cryopreservation) Storage
ARS Fort Collins

Transfer of Coffee from HARC to Hilo

Coffee plants at HARC, University of Hawaii and grower fields sent to Dapeng ARS Beltsville for genotyping

Seeds germinated in Hilo, in greenhouse before planting

Coffee branches bagged before flowering, cherry collected, and seeds sent to Hilo

Single-Nucleotide Polymorphisms (SNPs)
Dr. Dapeng Zhang, ARS Beltsville

A SNP is a single base change in a DNA sequence that occurs in a significant degree (>1%) within a population

```
ACGTGAATTCACTAG
ACGTGAATTCACTAG
ACGTGAACTCACTAG
ACGTGAATTCACTAG
ACGTGAACTCACTAG
ACGTGAATTCACTAG
```

Select a small SNP panel for genotyping Arabica coffee

132 accessions from CATIE International Coffee Collection

1) Typica/Bourbon
2) East African varieties
3) Ethiopian landraces and wild germplasm
4) Introgressed varieties
5) C. canephora

Merot-L'Anthoene et al., 2019. Development and evaluation of a genome-wide coffee 8.5K SNP array and its application for high-density genetic mapping and for investigating the origin of Coffea arabica L. Plant Biotechnol J. 17:1418–1430.

Zhang et al, ASIC 28th Conference 2021

Material and Methods

Code	Name	Chr.	Location	SNPs and flanking sequences
Ca4929	chr6_295208	Chr6	295268	ATCTTCTTACCGACACCCCAACGACAAGAAAGTGTCCAGTAGAGGTGCAATCGGGTCGGG[T/G]TCGGGTTGACGGGTCGGGTTGGGCTTAAGTATAGCAAAGAACCTGCTGAATCGAATCCGA
Ca0360	chr1_299891	Chr1	299951	TGCTTATTTAGCCAATCAGAAAAAAGGCAGGACAAAAATTTCATGAACCAACAATATAAC[C/G]CTGAATTAGAGAAAATCGTTCAAAACATTTTTTCGTCCTTCACTTTTAAAATTGTTGTTT
Ca6722	chr9_387547	Chr9	387547	CGCAACATTTTCCTTTTTACAGTTCTTAATTAGTATTTCTCCGAGACAAGCCTAACCCTC[A/G]AGGAGATCAACCGATCAAGGAAGAAGAAGTCTGTGGAAAATATGAGAATTGAAAGACATC
Ca1075	chr10_392529	Chr10	392589	TTCCATTCCCCGCATGATCCTCTTTCCTCGATCATTTCCCTTTGCTCGACACTCTTTTCT[T/G]GCTCTCATTTACTCTAGTTTCATTTTTCCTCCCGTCAAATCTTTGTTGAGAGGGAGAGCA
Ca1695	chr11_544708	Chr11	544708	ACTATCCCAGGGTCACCAGCTACCCGACGGAGTCCGCTTATGGCTCGAGTCGACTAGCAA[A/T]GAAGAACAAGGGCCCAATTCAGTCAAAAGGCTTGTATACATGCACAAGTTGTATTCAATC
Ca5205	chr6_714601	Chr6	714661	GTGGTCATCACCCTCTTTGGTGATACTGGAAGTTAGGGTTCTACCCTTGCCTCTCTCAAA[T/C]TTGCCACAATATGTGATTGGTCTTAGTTGACCATCTCCTCTTACCCCTTTCCCCTAGATT
Ca3400	chr3_765963	Chr3	765963	TACTTCACTATGCCCTTGATATGCATTCATCATGTAGATTGACTTTTTAGAAGTTTGTTT[T/G]GCCATGTATGCCAATGGAAATTATAGCTTTCCAATTAAATGGAAGTATCCTTGTATCTTT
Ca6385	chr8_777237	Chr8	777297	TGAAAAGATAGAAGGCAGATTAAAAGTTGTGTACACCTTTAGCAGCAAAGGCACTCTGGC[A/C]TTTCCACACCAAATTCCACATCGATTCTCGGGGAGGTTAAGGGTTAGGTTATTAATTTTC
Ca5810	chr7_836219	Chr7	836279	AGACATAAATAAGGATCAGGCCATATCTTTAATCATGTACAAACAGAAAGAGAGAGGGCA[C/G]TTATGAACAGACAGAAACATTATAAATGCAACAGCCAACAGAACAAGAATTGATTGTTGG
Ca5818	chr7_862782	Chr7	862842	CAAGGGAAATTTTTAGCACAGGTACAAATTTATCGTTTTCTTTCTTTCTATTCCTTTTGC[T/C]TCACAGGCTAAATCCATTCAAATGTTGAAACTTAAGAGATTGTAGAACTACTTGTCCTAA
Ca5821	chr7_879665	Chr7	879725	CTCTCGACTCTCTCCCCAGCCTCCTCTACTTGTGTGCGTGGCCTTGGGCTTTGTCTAATC[A/T]CTCTCGACCGAATCGGATAACGCCTACGCCGTCTCCTCTTCGCTTCTTTGTTTTTTCGCC
Ca5304	chr7_1034040	Chr7	1034100	GCACCATTAGTGTGAGTAAGATTAATATGTAAAAGTTACATGTCCAAGTCATGATTGAAT[T/G]ACAGGTAACAATTCAAATTTAAGAGAATGCCAATTAAGTGCATGTGTTCAAAGTAGAAAA
Ca0079	chr1_1224907	Chr1	1224907	TGGTGAAGCCAAGAAATAATGAGAAAGTGATTGGCTGGTCCATGCACTTGTTTGTATTAG[T/C]GGTAGGGTCGTGCAGTACGCTTTTAGCCAATGTTTTAAAACCCGGACCGTCAACTGAATC
Ca3794	chr4_2625820	Chr4	2625880	TGGAGGCAAAGTTGGAAGAAACAAGACGCAAGGAGAAAATGATGAAATTGTTGCTGTTTG[T/C]AGCGTTTGTTTTCGTAGTGCAGAATTTGTTGAGCAAATATTGAGTTGTAACAAGCATTTG

Zhang et al., 2021. Selecting a core set of nuclear SNP markers for molecular characterization of Arabica coffee (Coffea arabica L.) genetic resources. Conservation Genetics Resources. https://doi.org/10.1007/s12686-021-01201-y.

Results

Example of intra-varietal heterogeneity in Arabica coffee

Variety	homozygous loci (%)	chr2_1(	chr4_2:	chr5_2(	chr7_8(	chr8_5:	chr6_3(	chr9_6:	chr7_2:	chr1_2:	chr2_1	chr4_2(	chr7_8:	chr8_5:	chr1_2:	chr2_1:	chr5_2:	chr8_1:	chr8_7:	chr2_1:	chr6_1:
A14_1	0.814	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_2	0.871	C C	A A	A A	T T	A A	T T	T T	A G	G T	G G	C T	A A	C C	T T	C C	C C	C C	C C	G G	A G
A14_3	0.814	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_4	0.786	C C	A A	A A	C T	A A	T T	G T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_5	0.829	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_6	0.871	C C	A A	A A	T T	A A	T T	T T	A G	G T	G G	C T	A A	C C	T T	C C	C C	C C	C C	G G	A G
A14_7	0.829	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_8	0.814	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_9	0.829	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_10	0.814	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_11	0.829	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_12	0.871	C C	A A	A A	C C	A A	T T	T T	A G	G T	G G	C T	T T	C C	T T	0 0	C C	C C	C C	G G	A G
A14_13	0.857	C C	A A	A A	C C	A A	T T	T T	A G	G T	G G	C T	T T	C C	T T	C C	C C	C C	C C	G G	A G
A14_14	0.814	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_15	0.800	C C	A A	A A	C T	A A	T T	T T	A G	G T	G G	C T	A T	C C	T T	C C	C C	C C	C C	G G	A G
A14_16	0.729	T T	T T	A A	C C	A A	A T	T T	G G	G T	G G	C T	T T	C C	T T	A C	C C	C C	C C	G G	A G
A14_17	0.814	C T	A T	A A	T T	A A	T T	T T	G G	G T	G G	C T	A A	C C	T T	A C	C C	C C	C C	G G	A G
A14_18	0.814	C T	A T	A A	T T	A A	T T	T T	G G	G T	G G	C T	A A	C C	T T	A C	C C	C C	C C	G G	A G
A14_19	0.814	C T	A T	A A	T T	A A	T T	T T	G G	G T	G G	C T	A A	C C	T T	A C	C C	C C	C C	G G	A G
A14_20	0.757	C T	A T	A A	C T	A A	T T	T T	G G	G T	G G	C T	A T	C C	T T	A C	C C	C C	C C	G G	A G
IH-2-1	0.886	T T	T T	A A	C C	T T	T T	G G	G G	G G	C C	C C	T T	G G	A A	C C	A A	C G	C C	A A	A G
IH-2-2	0.914	T T	T T	A A	C C	T T	A A	G G	G G	G G	C C	C C	T T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-3	0.886	C T	A A	A A	T T	T T	T T	G G	G G	0 0	G G	C T	A A	C C	A A	C C	A A	C G	C C	A A	A G
IH-2-4	0.843	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-5	0.843	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-6	0.829	T T	A T	A A	T T	A T	T T	G G	G G	G G	C C	C T	A A	C C	A A	C C	A A	C G	C C	A A	A G
IH-2-7	0.871	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-8	0.900	C C	T T	A A	T T	A A	T T	G G	G G	G T	G G	C C	A A	C C	A A	C C	A A	C G	C C	A A	A G
IH-2-9	0.871	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-10	0.871	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-11	0.857	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-12	0.900	T T	T T	A A	C C	T T	A A	G G	G G	G G	C C	C C	T T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-13	0.857	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-14	0.857	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-15	0.871	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-16	0.857	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-17	0.914	T T	T T	A A	C C	T T	A A	G G	G G	G G	C C	C C	T T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-18	0.857	T T	T T	A A	C T	T T	A A	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G
IH-2-19	0.600	T T	A T	A T	C T	T T	A T	G G	G G	G G	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	A G
IH-2-20	0.829	T T	T T	A A	C T	T T	A A	G G	G G	0 0	C C	C C	A T	G G	A A	C C	A A	C G	C C	A A	G G

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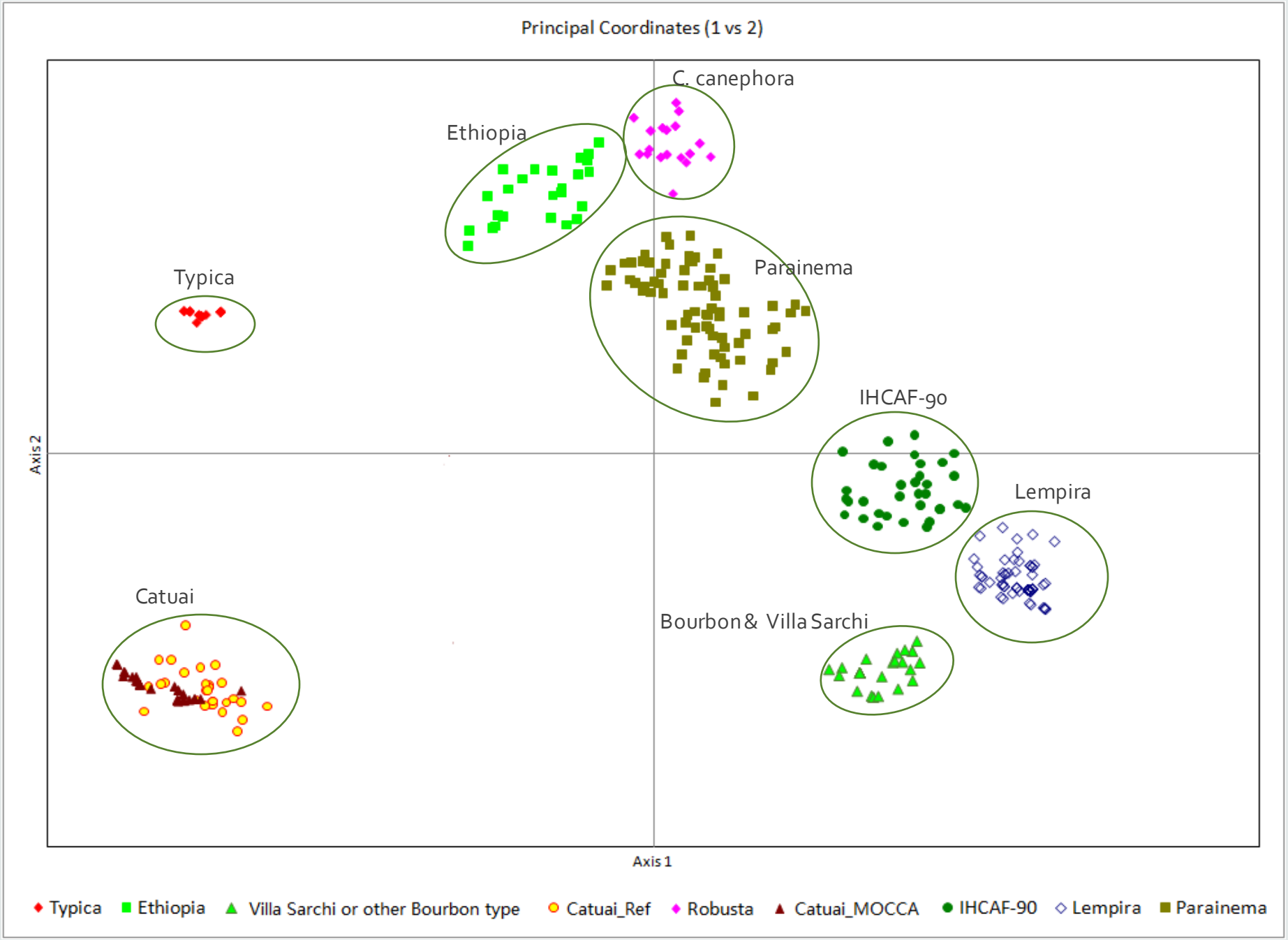

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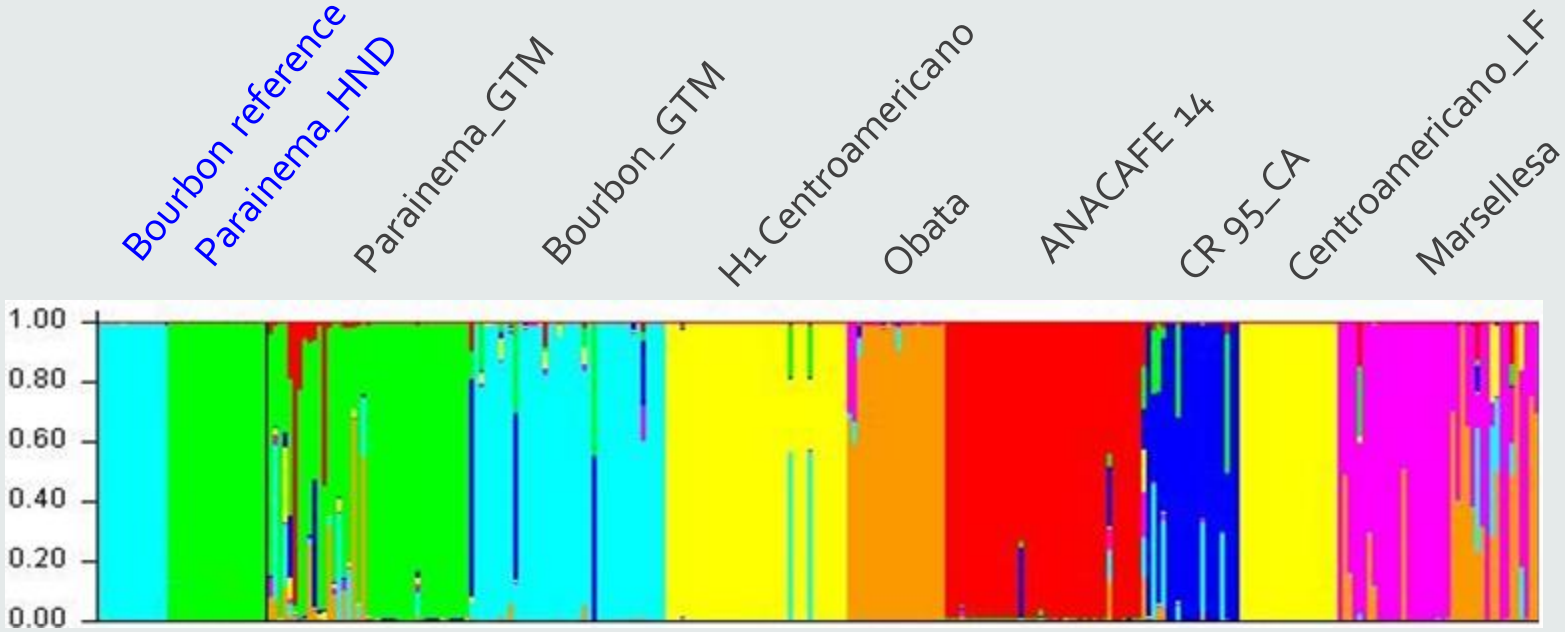
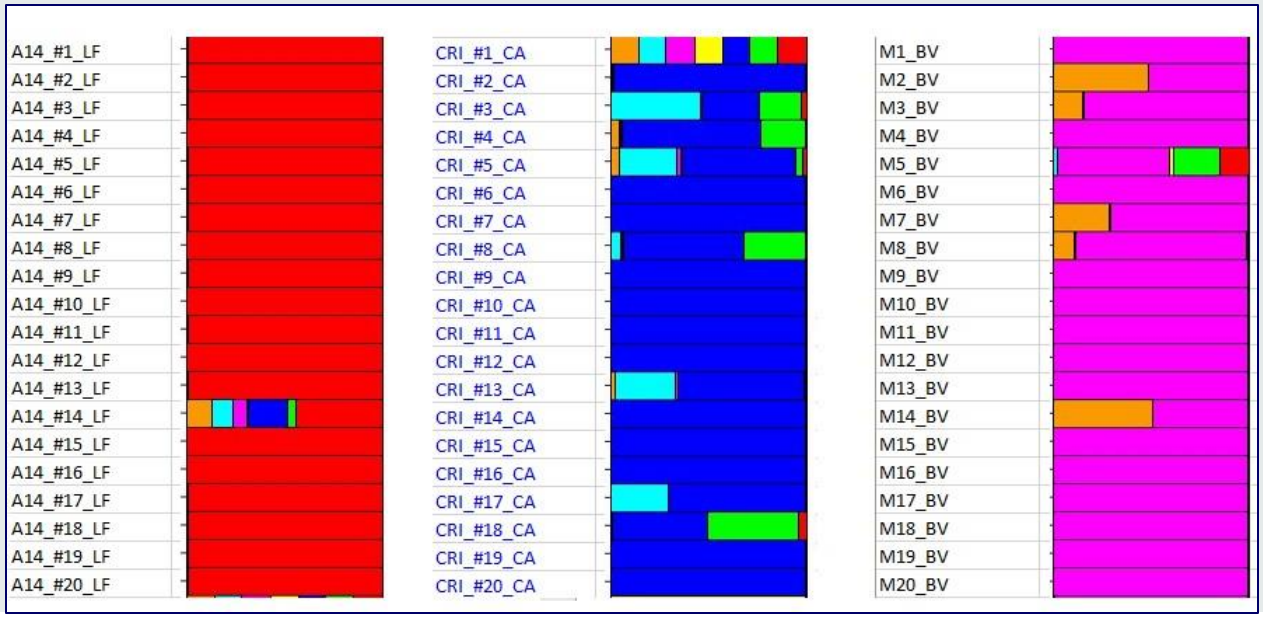
Detection of "offtype" trees





Zhang et al,
ASIC 28th Conference
2021

What's Next

Potential Downstream Applications

- Plant nursery accreditation
- Variety certification
- Product traceability & authentication
- Breeders right & IP protection

Future Research

- Expand the genotyping to include the full range of Arabica varieties;
- Develop diagnostic markers for mutation detection;
- Understand the genetic basis of residue heterozygosity;
- Investigate mating system for different varieties and different agroecology

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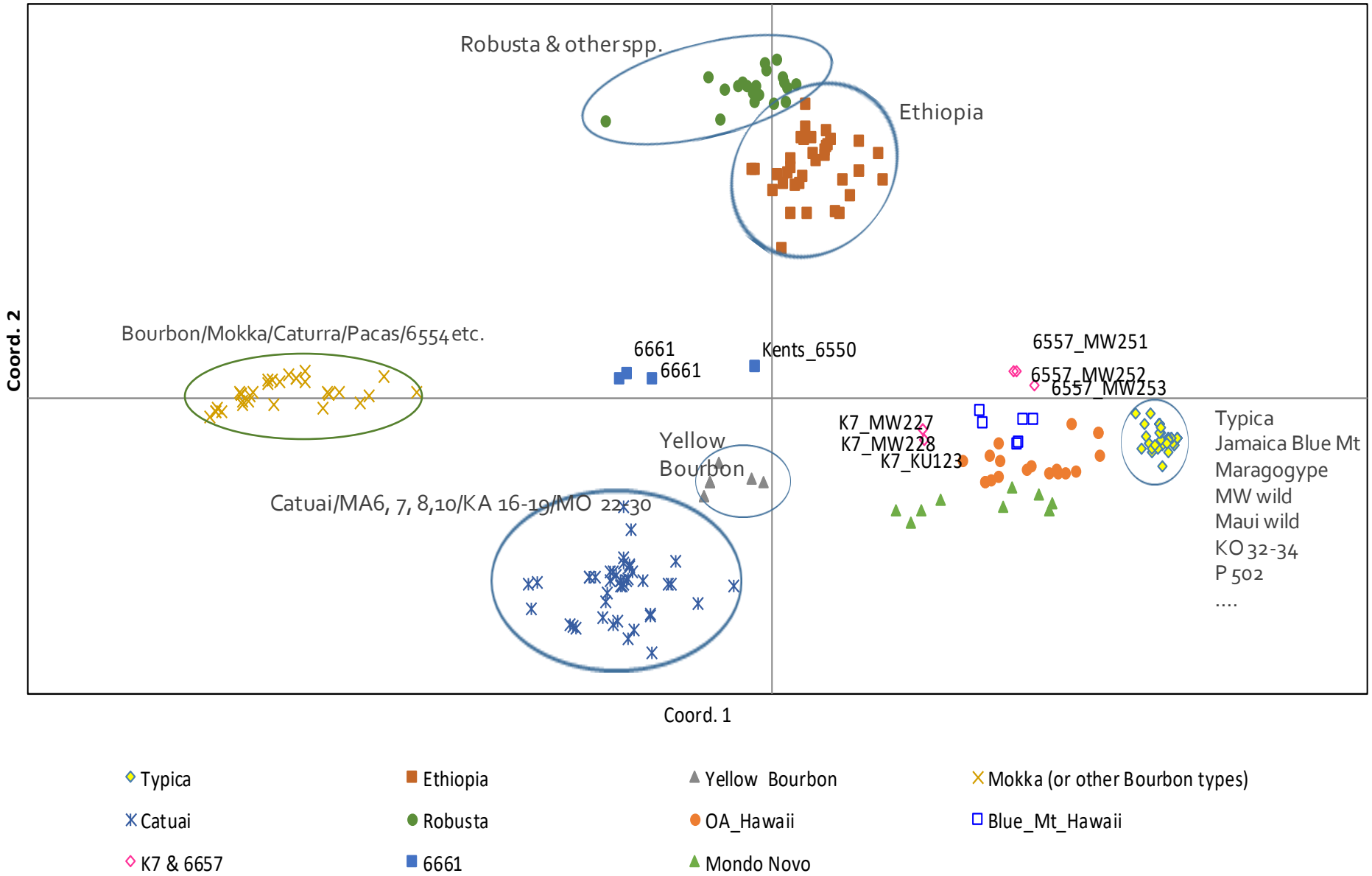
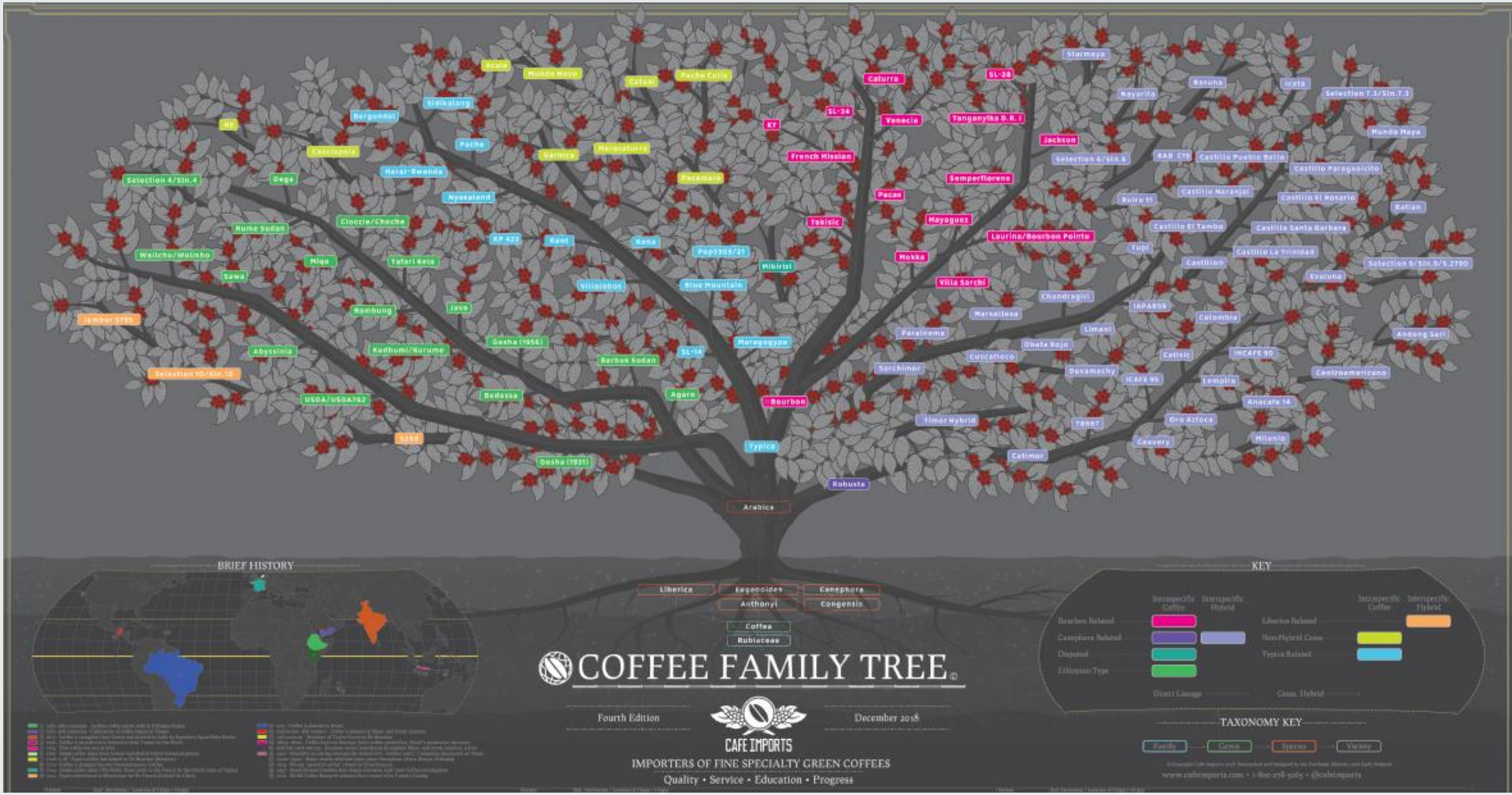
Main varieties/groups in the HARC collection



Diversity of Coffee Varieties



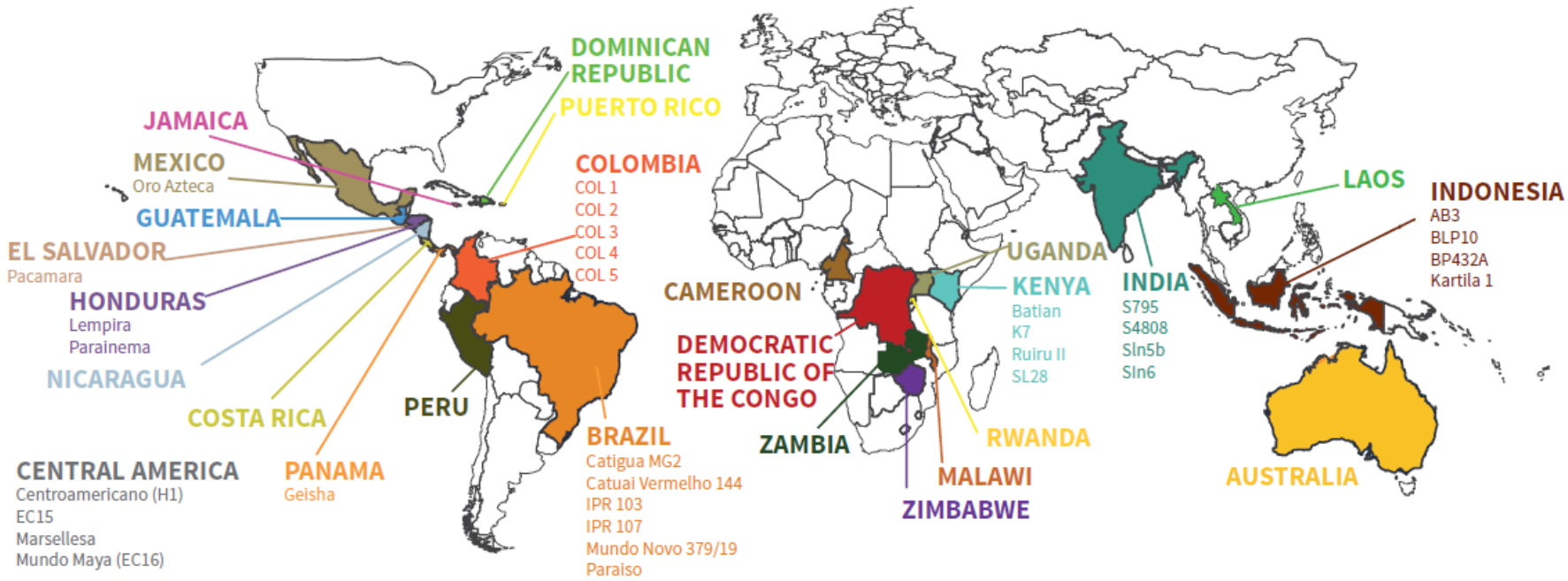
https://www.cafeimports.com/north-america/coffee-family-tree

HARC and USDA ARS PBARC participating in World Coffee Research International Multilocation Variety Trial

WORLD COFFEE RESEARCH

22 countries host IMLVT sites

NOTE: Countries/regions with varieties listed provided seeds and received plantlets. Countries without seeds listed are variety recipients only.



https://worldcoffeeresearch.org/work/international-multilocation-variety-trial/

Importation of IMLVT Coffee Lines

- Permit submitted to HDOA in 2017
- Plants scheduled to arrive in 2020 but delayed due to COVID
- Plant arrive on September 4, 2020
- Coffee Leaf Rust found on Maui in end of October 2020
- Petition to propagate plants under quarantine filed
- Petition granted to propagate plants in quarantine March 23, 2021

IMLVT Coffee Varieties in Tissue Culture

Susceptible

- AB3
- BLP10
- Catuai V IAC144
- Geisha
- K7
- Lempira
- Mundo Novo 379/19
- Pacamara
- SL28

Tolerant/Resistant

- Batian
- Catigua MG2
- Col1
- Col2
- Col3
- Col4
- EC15
- EC16
- Centroamericano H1
- IPR103
- IPR107
- Kartila 1
- Marsellesa
- Oro Azteca
- Parainema
- Paraiso
- Ruiru 11
- S4808
- S795
- SLN5B
- SLN 6

WCR Coffee Varieties Information

COFFEE VARIETIES

of Mesoamerica and the Caribbean

WORLD COFFEE RESEARCH

USAID FROM THE AMERICAN PEOPLE

PROMECAFE

CENTROAMERICA *H1*

28

Very high yielding variety if planted in healthy soil, with very good quality at elevations above 1300 meters. Well-adapted to agroforestery conditions.

QUALITY POTENTIAL AT HIGH ALTITUDES	YIELD POTENTIAL	STATURE	OPTIMAL ALTITUDE
Very Good	Very High	Dwarf	800–1500 meters

COFFEE LEAF RUST	NEMATODES	COFFEE BERRY DISEASE (CBD)	YEAR OF FIRST PRODUCTION
Resistant	Tolerant	Tolerant	Early

NUTRITION REQUIREMENT	BEAN SIZE	LEAF TIP COLOR
Very High	Large	Green

RIPENING OF FRUIT	Average
CHERRY-TO-GREEN-BEAN OUTTURN	Very High
PLANTING DENSITY	Bourbon-like (3000-4000 a/ha)
ADDITIONAL AGRONOMIC INFORMATION	Can have difficulty establishing roots in the first two years caused by desequilibrium between the growth of radicle roots and aerial roots. Requires careful nutrition for roots to become established, avoiding too much nitrogen (N). Note: Seeds taken from hybrid plants will not have the same characteristics as the parent plants. This is called "segregation." It means that the child plant will not look or behave the same as the parent, with potential losses of yield, disease resistance, quality, or other agronomic performance traits. The variety should only be reproduced through clonal propagation. Nematodes: Not tolerant to *Pratylenchus spp.* Is tolerant to *Meloidogyne exigua*

INTELLECTUAL PROPERTY RIGHTS	This plant is in the public domain in Costa Rica, El Salvador, Guatemala and Honduras; outside of these countries, permission should be requested from PROMECAFE.
BREEDER	CIRAD-CATIE-ICAFE-IHCAFE-PROCAFE-ANACAFE
GENETIC DESCRIPTION	Hybrid (Ethiopian x Catimor/Sarchimor)
PARENTAGE	TS296 x Rume Sudan

WHERE TO FIND
For up-to-date information on whether its possible to obtain this variety through the World Coffee Research Verified program, please visit our website:

https://varieties.worldcoffeeresearch.org/varieties/centroamerica

UPDATED
Jun 07, 2016

https://varieties.worldcoffeeresearch.org/varieties

Hawaii Coffee Variety Trials

Locations: Kauai, Oahu, Maui, and Kona

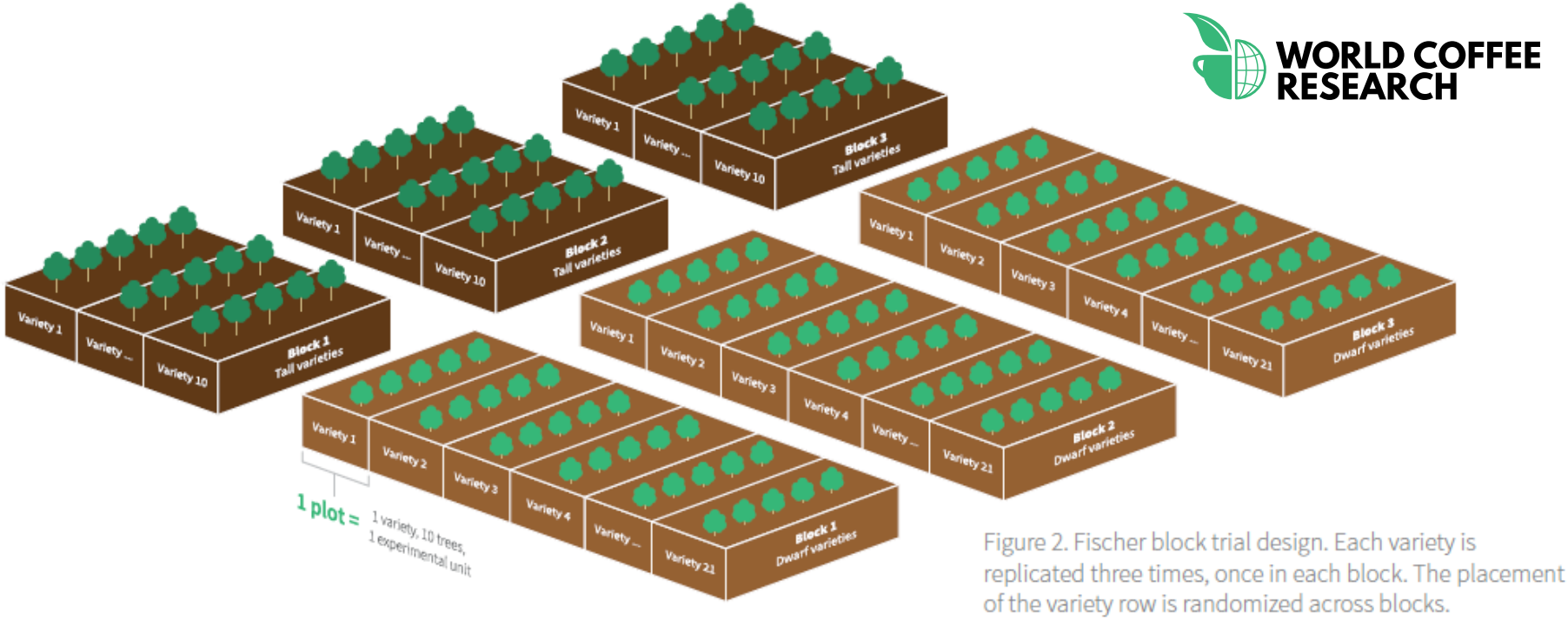


Figure 2. Fischer block trial design. Each variety is replicated three times, once in each block. The placement of the variety row is randomized across blocks.

Data:

- vegetative growth (tree height and diameter, etc)
- CLR incidence and severity, other pest and disease incidence
- flowering data (start date of flowering, date of peak flowering and date of last flowering)
- cherry phenology data (size and maturation)
- production data (date and weights of harvest)
- bean quality (weight of bean, size, imperfections, and grade)
- cupping quality

Other Ongoing Activities

- Negotiation with Breeders of Coffee Varieties in WCR IMVLT
- Investigating other potential varieties for Hawaii
- Potential importation through USDA APHIS Controlled Import Permit

Acknowledgements

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Chifumi Nagai
Ming Li Wang
Sayaka Aoki

WORLD COFFEE RESEARCH

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Jorge Benny

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USDA

Dapeng Zhang
Ricardo Goenaga
Tomas Ayala Silva

Coffee Strategic Plan Variety

Chifumi Nagai
Noel Arrieta
Luis Aristizabal
Andros Bracamontes
Miguel Meza

Arturo Correa

Mahalo!
Tropical Plant Genetic Resources and Disease Research Unit

Questions?