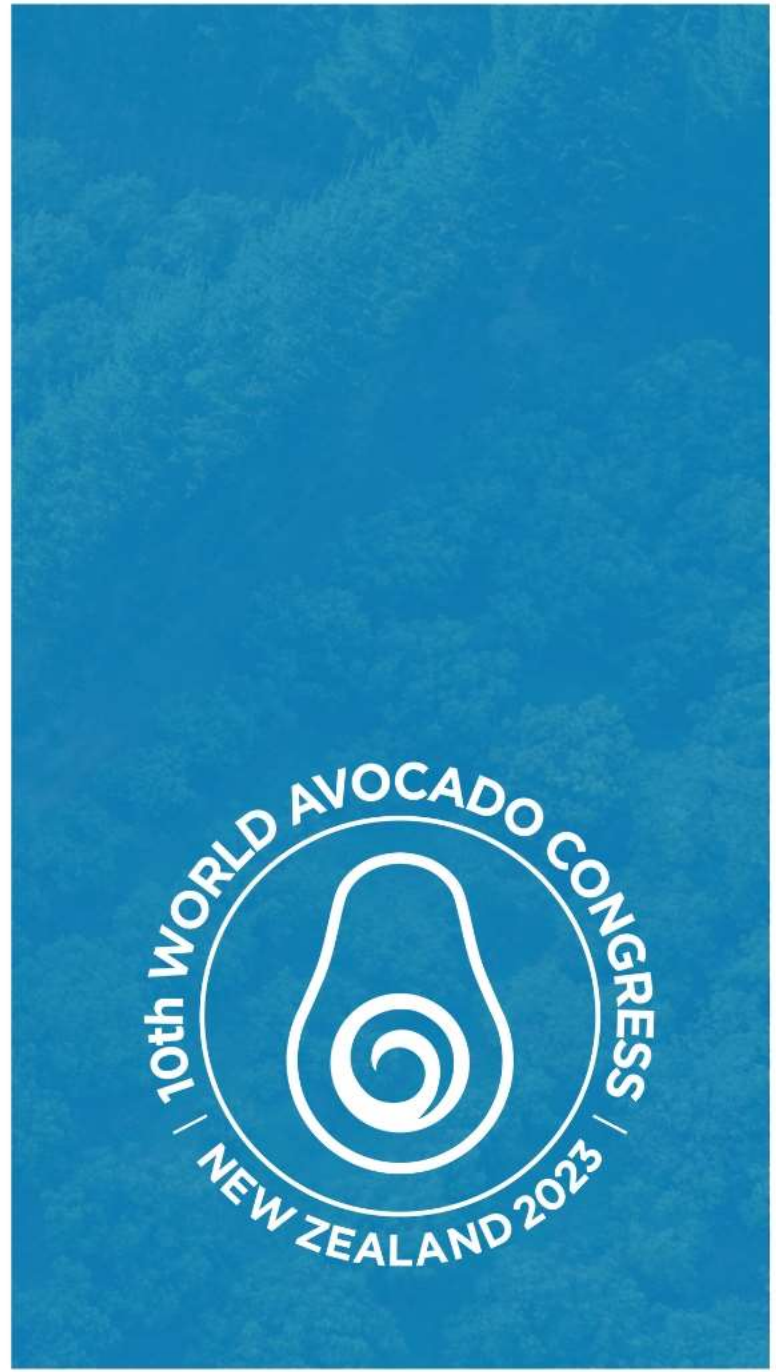
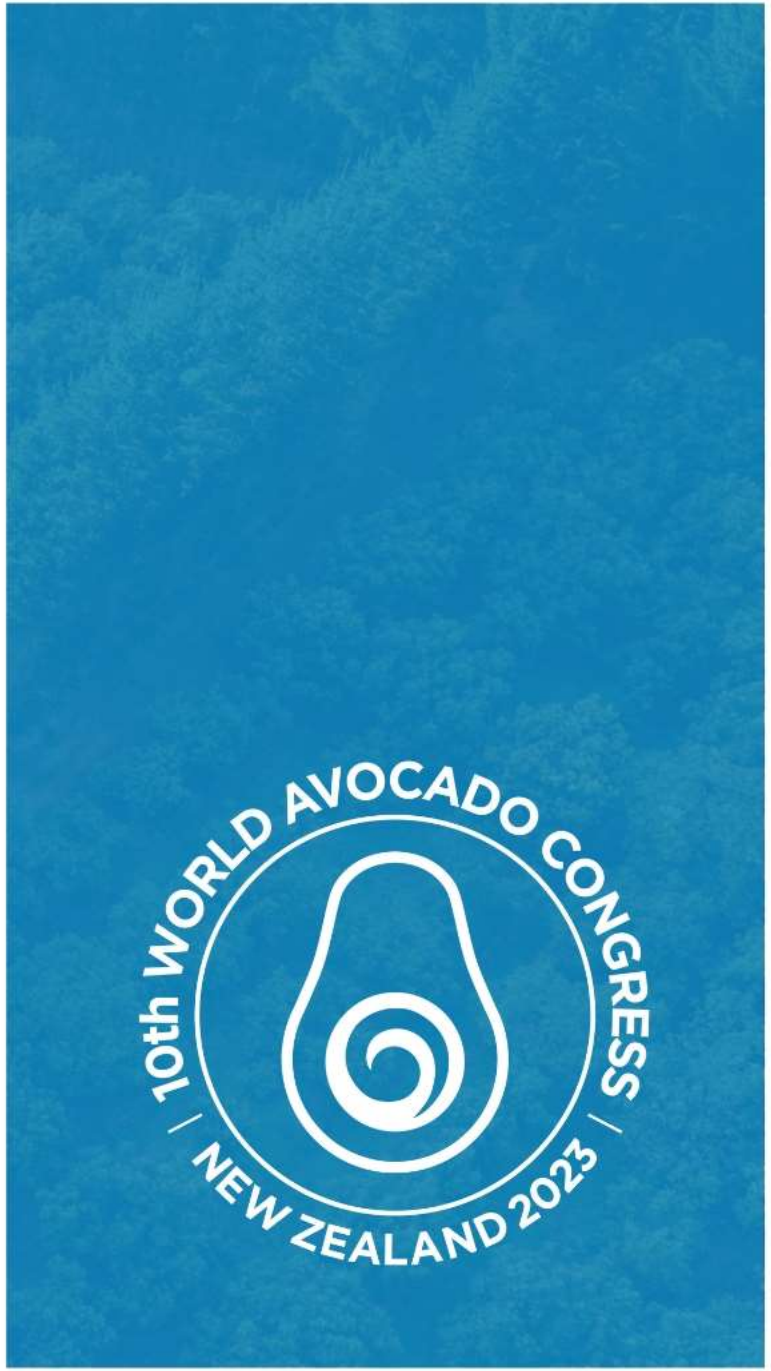
Genomics

Chair: Neena Mitter



The USDA avocado germplasm collection: Genetics, genomics, phenomics and uses

Gul Ali



The USDA Avocado Germplasm Collection: Genetics, genomics, phenomics and uses.

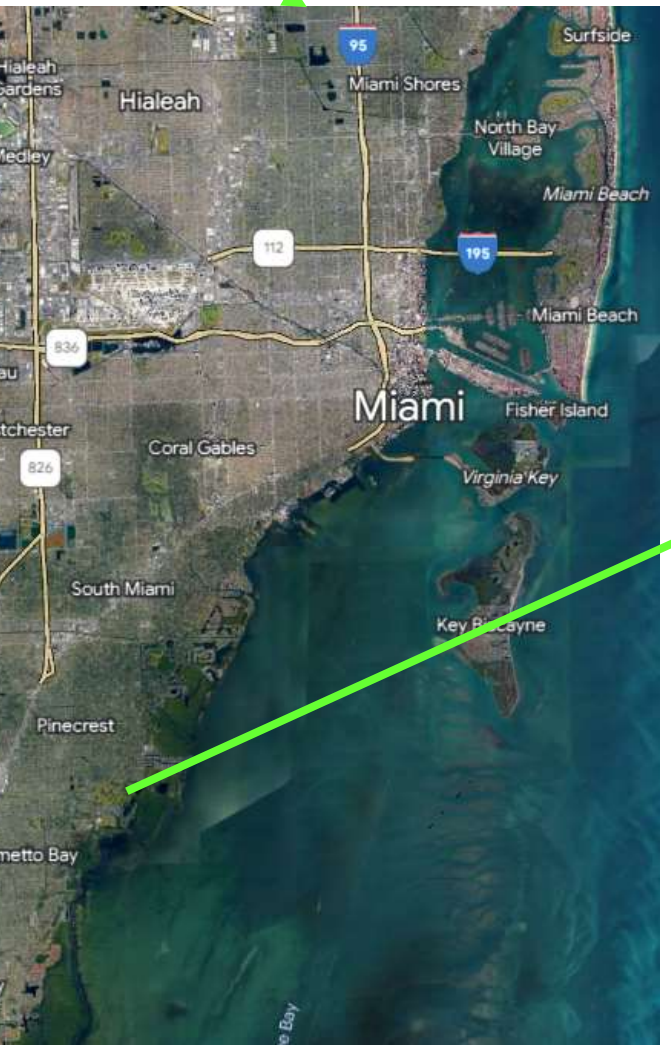
Colección de germoplasma de aguacate del USDA: genética, genómica, fenómica y usos.

April 2, 2023
World Avocado Congress, Auckland, New Zeland

Gul Shad Ali
Geneticist (Plants)

United States Department of Agriculture
Agricultural Research Service
Subtropical Horticulture Research Station, Miami, FL 33158

Subtropical Horticulture Research Station, Miami, FL

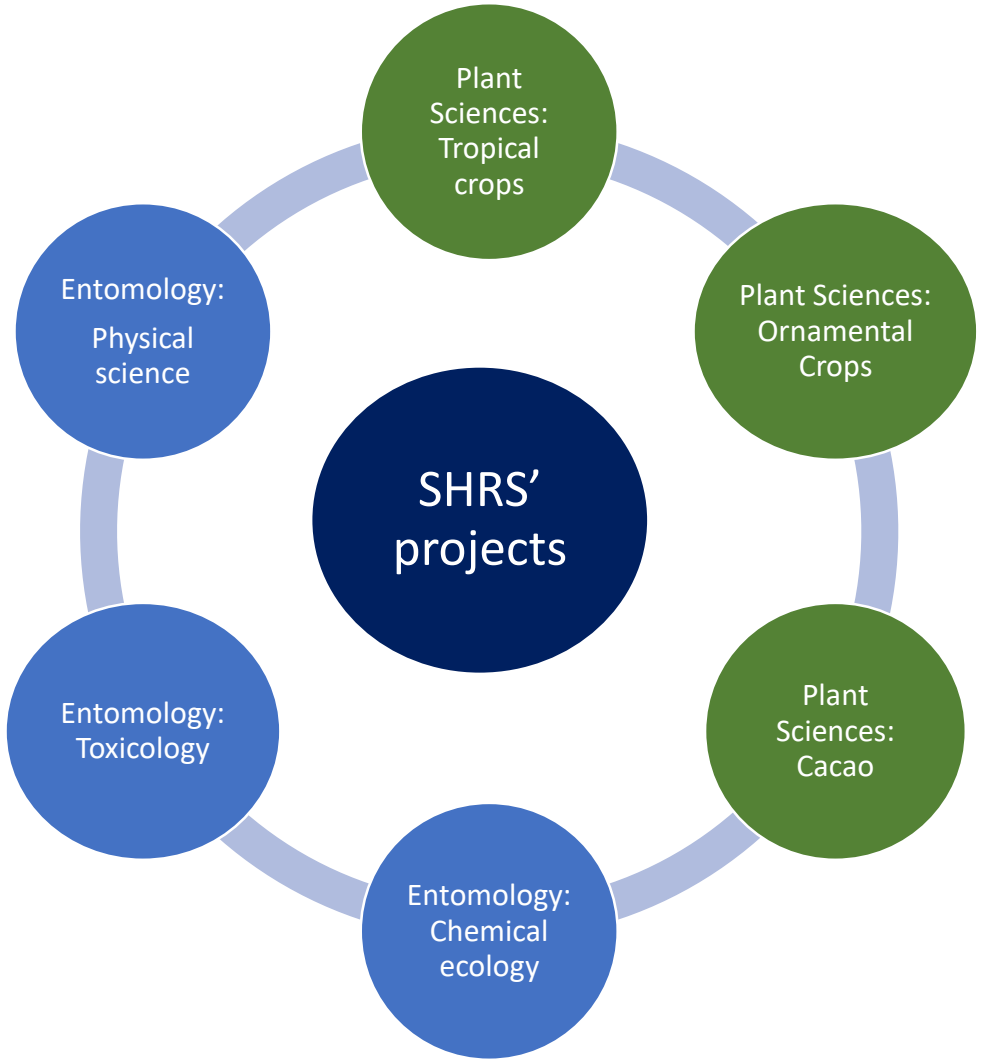


The USDA National Plant Germplasm System

- College Station & Somerville, Texas Genebank - pecans
- Corvallis, Oregon Genebank - pears, hazelnuts, small fruits, mint, hops
- Davis California Genebank - stone fruits, grapes, other fruits & nuts
- Geneva, New York Genebank - apples, tart cherries, hardy grapes
- Hilo, Hawaii Genebank - subtropical and tropical crops
- Miami, Florida Genebank - subtropical and tropical crops
- Mayaguez, Puerto Rico Genebank - subtropical and tropical crops
- Riverside, California Genebank - citrus and dates
- Washington, D.C. National Arboretum - Discover
- Aberdeen, Small Grains and Potato Germplasm Research
- C.M. Rick Tomato Genetics Resource Center, Davis, California (external link)
- Genetic Stocks - Oryza (GSOR) Collection, Stuttgart, Arkansas
- Maize Genetics Cooperation - Stock Center (GSZE), Urbana, Illinois (external link)
- G.A. Marx Pea Genetic Stock Center (GSPI), Pullman, Washington
- National Arid Land Plant Genetic Resources Unit (PARL), Parlier, California
- National Center for Genetic Resources Preservation (NCGRP), Fort Collins, Colorado
- National Small Grains Collection (NSGC), Aberdeen, Idaho
- National Temperate Forage Legume Genetic Resources Unit, Prosser, Washington
- North Central Regional Plant Introduction Station (NC7), Ames, Iowa
- Ornamental Plant Germplasm Center (OPGC), Columbus, Ohio
- Plant Genetic Resources Conservation Unit, Griffin, Georgia
- Plant Genetic Resources Unit, Geneva, New York
- Soybean/Maize Germplasm, Pathology, and Genetics Research Unit, Urbana, Illinois
- United States Potato Genebank - NRSP-6, Sturgeon Bay, Wisconsin
- Western Regional Plant Introduction Station, Pullman, Washington
- Wheat Genetic Stock Center (GSTR), Aberdeen, Idaho
- Desert Legume Program, Tucson, Arizona (external link)

Research Components at SHRS

- ***Dr. Paul Kendra*** *(Research Entomologist, Lead Scientist)*
- ***Dr. Nurhayat Tabanca*** *(Research Chemist)*
- ***Dr. Xiangbing Yang*** *(Research Entomologist-Toxicologist)*
- ***Dr. Kevin Cloonan*** *(Research Entomologist-Chemical Ecologist)*
- ***Dr. Barukh Rohde*** *(Research Physical Scientist)*

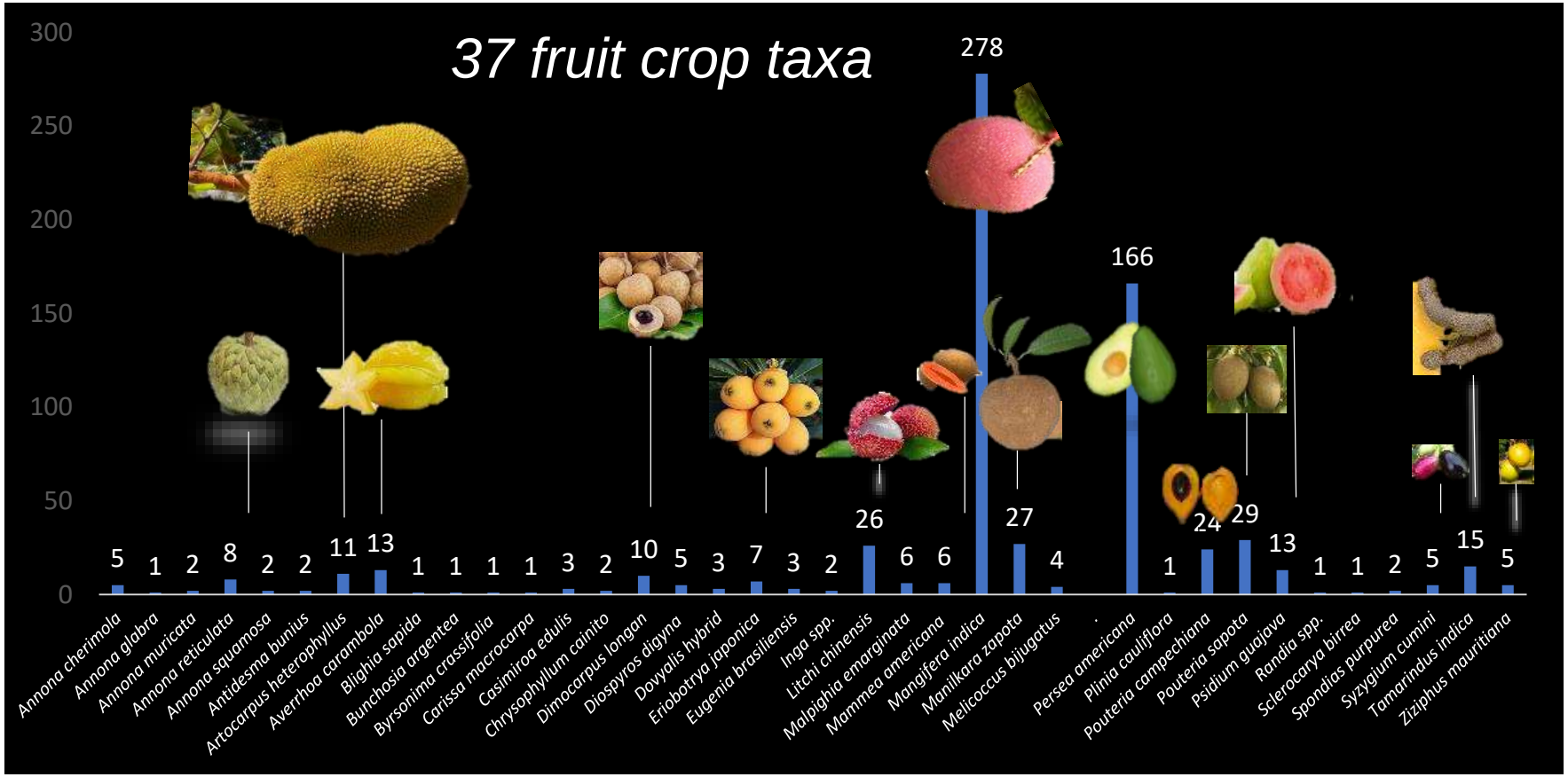


Dr. Gul Shad Ali *(Geneticist, Plants, Tropical Crops)*

Dr. Madhugiri Nageswara-Rao *(Geneticist, Plants, Ornamentals)*

Dr. Osman Gutierrez *(Research Geneticist, Cacao)*

Tropical crops genetic resources at USDA-SHRS, Miami, FL



974

1118

122

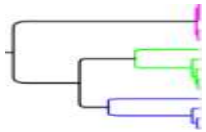
Vision and mission

Vision: Enhancing genetic resources are essential for agricultural sustainability and environmental stewardship.

Mission: To preserve, characterize, improve and distribute germplasm for enabling resilient tropical/subtropical fruit and sugarcane varieties.

USDA/ARS Mission: *Find Solutions to Agricultural Problems that Affect Americans Every Day, From Field to Table.*

Objectives of the Tropical Crops Project at SHRS



(2)
Evaluation
Characterization

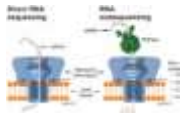
(1)
Acquisition
Maintenance
Propagation
Distribution

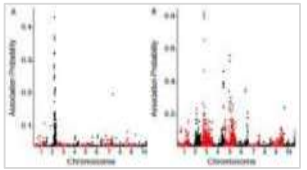
Germplasm

(3)
Genetics
Genomics
Botanical studies

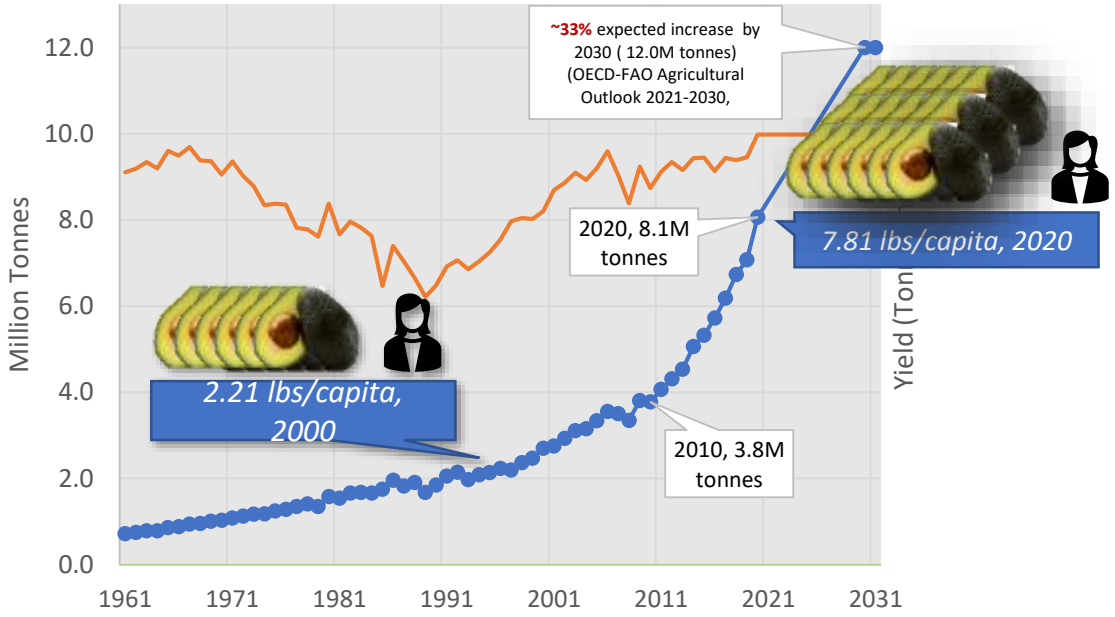
(5)
Reporting
Coordination
Collaborations

(4)
Update, implement, and develop alternative methods



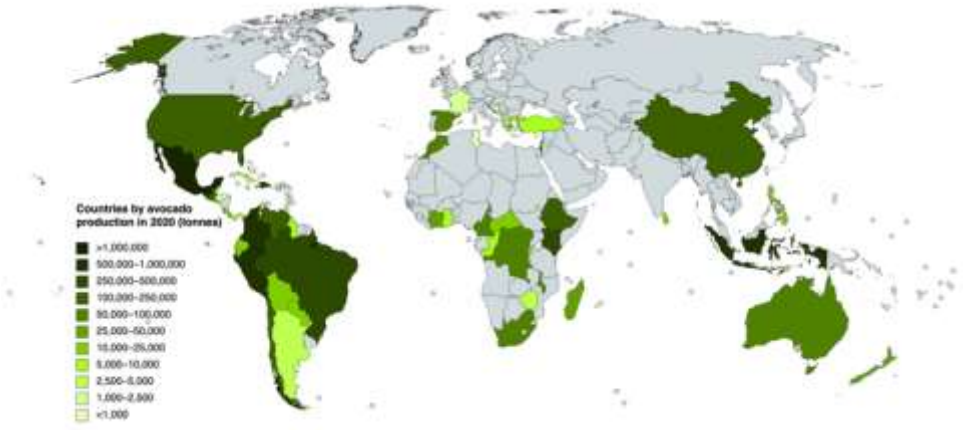


Avocado consumption trends



Avocado production & consumption trends

60+ countries



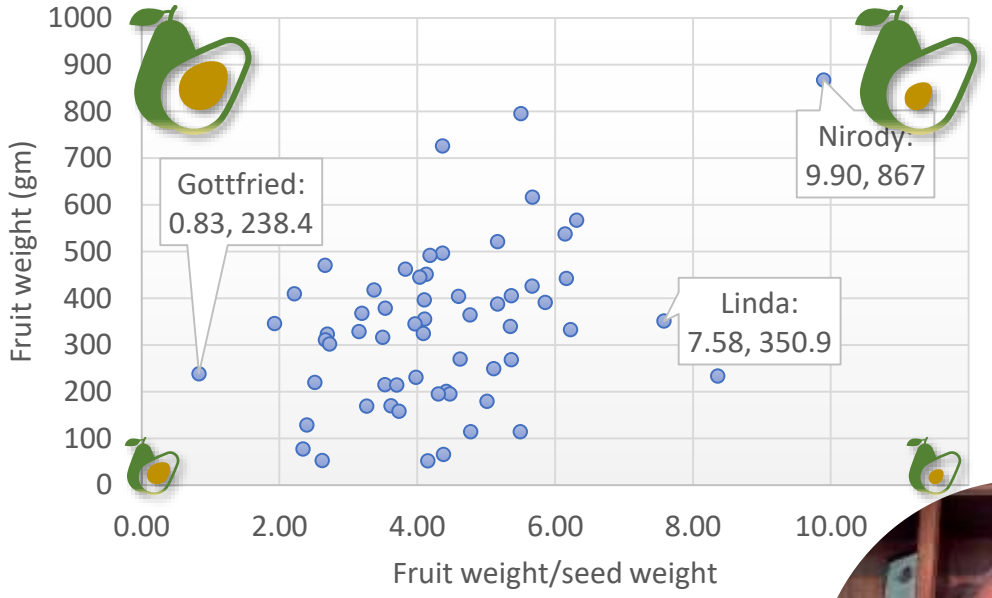
Statistica, NASS, 2021

The Avocado main collection at SHRS

Accessions (# at SHRS) 165	Characteristics of avocado accessions
Mexican (M) 23	Semitropical, most cold tolerance, least salt tolerance, highest oil content.
Guatemalan (G) 18	Subtropical, intermediate cold and salt tolerance, high oil content.
West Indian (W) 28	Tropical, least cold tolerance, most salt tolerance, low oil content.
G x M = 9 M x G = 1	3-5 crosses: Planned for the next 5 years
G x W = 15 W x G = 2	3-5 crosses: Planned for the next 5 years
M x W = 1	3-5 crosses: Planned for the next 5 years
G x M x W = 0	3-5 crosses: Planned for the next 5 years

Fruity traits variability in the *Persea* Collection at SHRS

- Tremendous variation in fruit quality traits
  - Fruit weight
  - Seed weight
  - Skin and flesh Color, Fruit length, width, thickness, diameter, shape, moisture, taste, water percentage, seed weight, width, length, thickness
  - Future traits: Canopy structure (CS), height (H), diameter at 1 meter Height (D1H), flowering time (FT), fruit maturity time (FMT), and fruit bearing regularity (FBR)



Nutritional descriptors

- 6 to 1 unsaturated to saturated fat ratio, rich in oleic acid
- low energy density of 1.6 kcal/g (79% of edible Hass avocado weight consists of water and fiber
- oleic acid and water emulsion increases carotenoid absorption from low-fat fruits and vegetables
- Multifunctional prebiotic and viscous fiber

Next 5-yr project plan

- Lipid analyses
- Vitamins
- Metabolites
- Minerals

- GC-MS/MS
- ICP-MS

Dreher, M.L., F.W. Cheng, and N.A. Ford, A Comprehensive Review of Hass Avocado Clinical Trials, Observational Studies, and Biological Mechanisms. Nutrients, 2021. ***13****(12)*

The Avocado genetic resources can be utilized for breeding *climate-smart* varieties

- Genetics and Genomic Selection
- Controlled-pollinated populations
- Open-pollinated populations

Persea spp. open-pollinated seedlings - 2022

- Currently genotyped and evaluated
- Current desirable traits:
  - Efficient water and nutrients usage – Root System Architecture
  - High density planting – canopy system studies

CULTIVAR	Race	# of seedlings
Galvan	W	120
Taylor		52
R21-T05	G	60
Suardia	G X W	202
Yon	G X W	36
Booth #1	UNK	72
Hickson	UNK	92
R14-T06	G	114
Queen 8	G	52
Queen 8	G	32
Queen 8	G	12
Avocatosa	G	28
Avocatosa	G	12
Melendez 2	W X G	55
Semil 43	G X W	36

Canopy Architecture Engineering: Towards identifying causal SNPs
combining Horticulture- Genetics – Genomics – Bioinformatics

Horticultural Phenotyping

Classical Genetics

	Dominant suppression		Complementary epistasis		Duplicate gene action		Single gene action		Observed	
	Expected numbers	*Expected ratio*	*Expected numbers*	*Expected ratio*	*Expected numbers*	*Expected ratio*	*Expected numbers*	*Expected ratio*		ratio
Round/Tall	90.1875	**13**	62.4375	9	104.0625	15	83.25	3	98	11.76
Flat/short	20.8125	**3**	48.5625	7	6.9375	1	27.75	1	22	3
Total		16		16		16		4		
CHISQ.TEST		**0.2418**		4.65671x E-10		0.00038		0.010007		

Genomics

Bulked Segregant analysis

Bulks	#
Short_blk1 (lf)	15
Tall_blk2 (hf)	19
Short_blk3 (hf)	8
Tall_blk4 (hf)	13
Parent_blk1	1
Parent_blk2	1

Bioinformatics

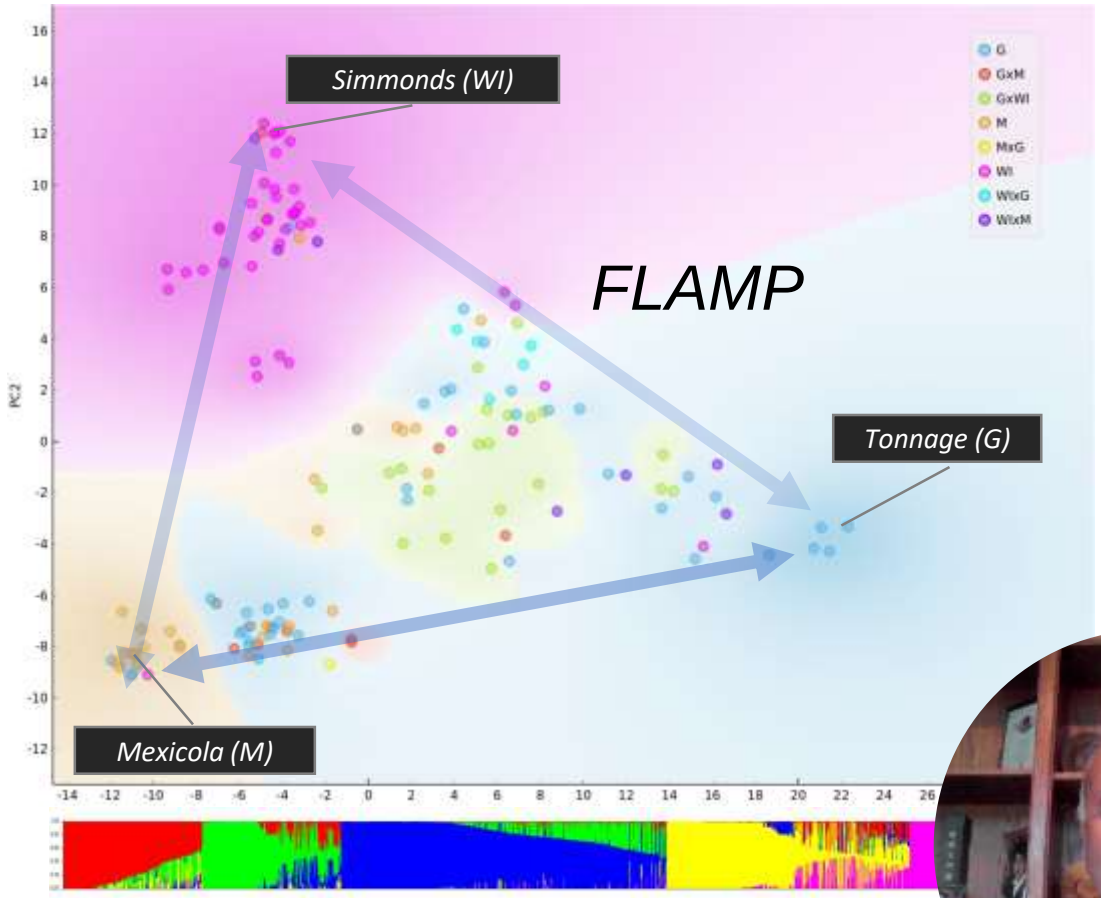
Markers development
Genomic Selection
Physiological studies

Post Doctoral Research Associate:
Opportunity is available for a talented self-motivated, self-driven individual with skills in ***genomics, bioinformatics*** *or* ***genome-wide association studies****.*

Genetics and genomics:

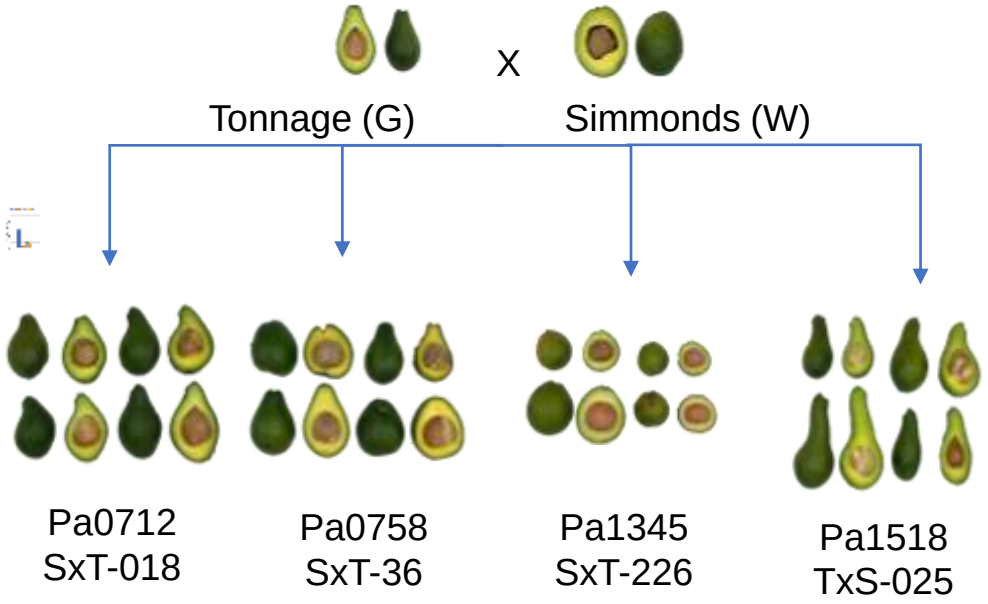
- Close Genetic gap
- Crosses planned in the next five-year project plan
- Increased genetic diversity
- Provide to stakeholders through GRIN-Global

SNP-based grouping of avocado collection



The Florida Avocado Mapping Population (FLAMP)

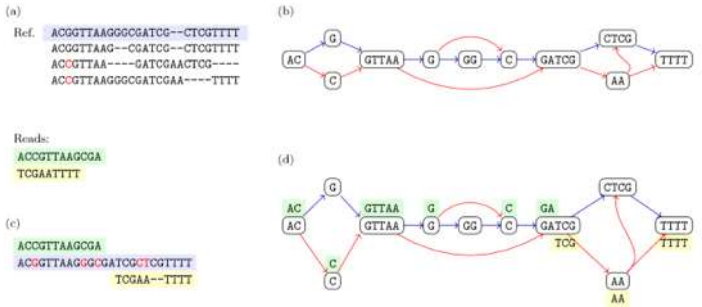
- *Displays variation:*
  - *fruit quality traits*
- Advancing the FLAMP to next generation
  - *Genetic studies*
  - *Heritability parameters for quantitative traits*



Genomics: whole genome resequencing, SNP genotyping and pangenome graphs

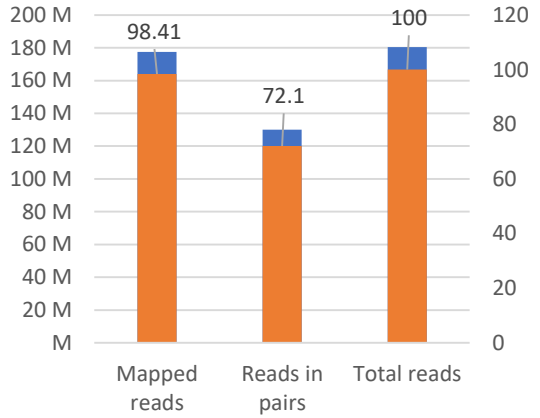
- Physical mapping
  - Optical mapping
  - Hi-C
- Sequencing
  - PacBio
  - NanoPore
- Pangenomes
  - Rare variant discovery
  - Population diversity

- Causal SNPs



Genome resequencing: Simmonds – selfed

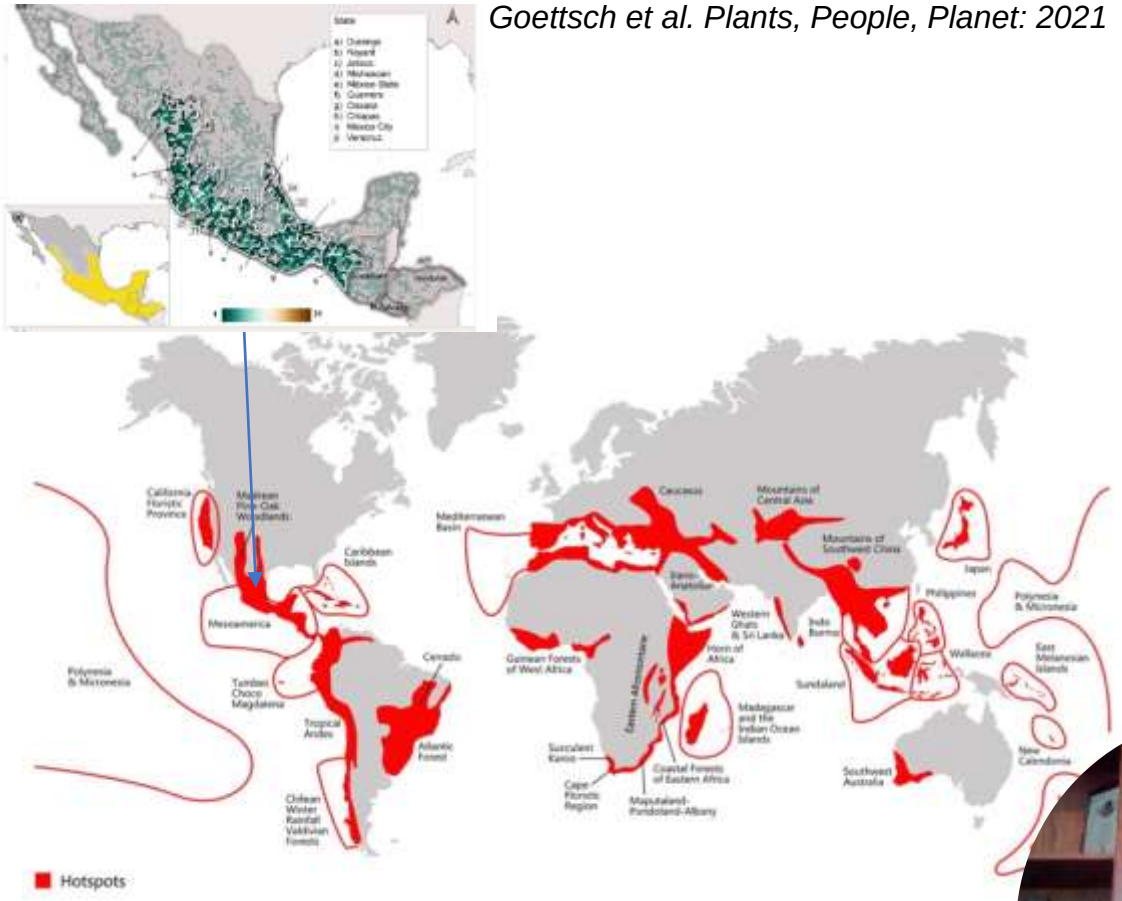
Total SNP: 24,379,709
Minor Allele Frequency:0.05
Coverage/Count: 20/8
Quality score: 200
Homopolymer removed:



In situ preservation and acquisition

- Suggestions:
  - **Save Crop Wild Relatives (CWR) in situ before they are lost.**
  - **Please contact me if you would like to donate Non-Proprietary avocado material to our Repository.**
  - **Will be put in tissue culture, genotyped and evaluated for traits.**
  - **Will be shared freely with the avocado research community through GRIN-Global**

Persea spp.



Goettsch et al. Plants, People, Planet: 2021

Avocado Preservation: Tissue culture and Cryopreservation

- Establish tissue culture facilities
- Share tissue culture protocols with stakeholders and research community
- Share tissue culture material with the research community through GRIN-Global

- Backed up at

USDA, ARS,
Tropical Plant Genetic Resources and Disease Research Unit

Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center
Hilo, HI 96720

Acknowledgements

The Tropical project staff -

- *Douglas DeStefano*
- *Barbara Freeman*

Admin staff

- *Karla Agurto & her Team*
- *Dr. Goenaga, RL*

Other staff

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- *Mike Winterstein,*
- *Chris Dunn,*
- *Hector Rodriguez,*
- *Ricardo Gonzalez,*
- *Brandon Rodriguez,*

The Ornamental project
The Entomology project
The Cacao project

Collaborators

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- Mention of trade names or commercial products in this presentation is solely for the purpose of providing specific information and does not imply recommendation or endorsement of the U.S. Department of Agriculture.