Improved tepary bean holds promise as a climate resilient pulse crop

Tim Porch, USDA-ARS-TARS

Mayaguez, Puerto Rico

Bean/Tepary field, Isabela Puerto Rico

Tepary field, Coolidge, Arizona, 1983

Burgess, 1983

USDA Agricultural Research Service

Tepary beans likely originated from the Sonoran desert

Probable domestication in Northern Mexico
(Garvin and Weeden, 1994; Blair et al., 2012)

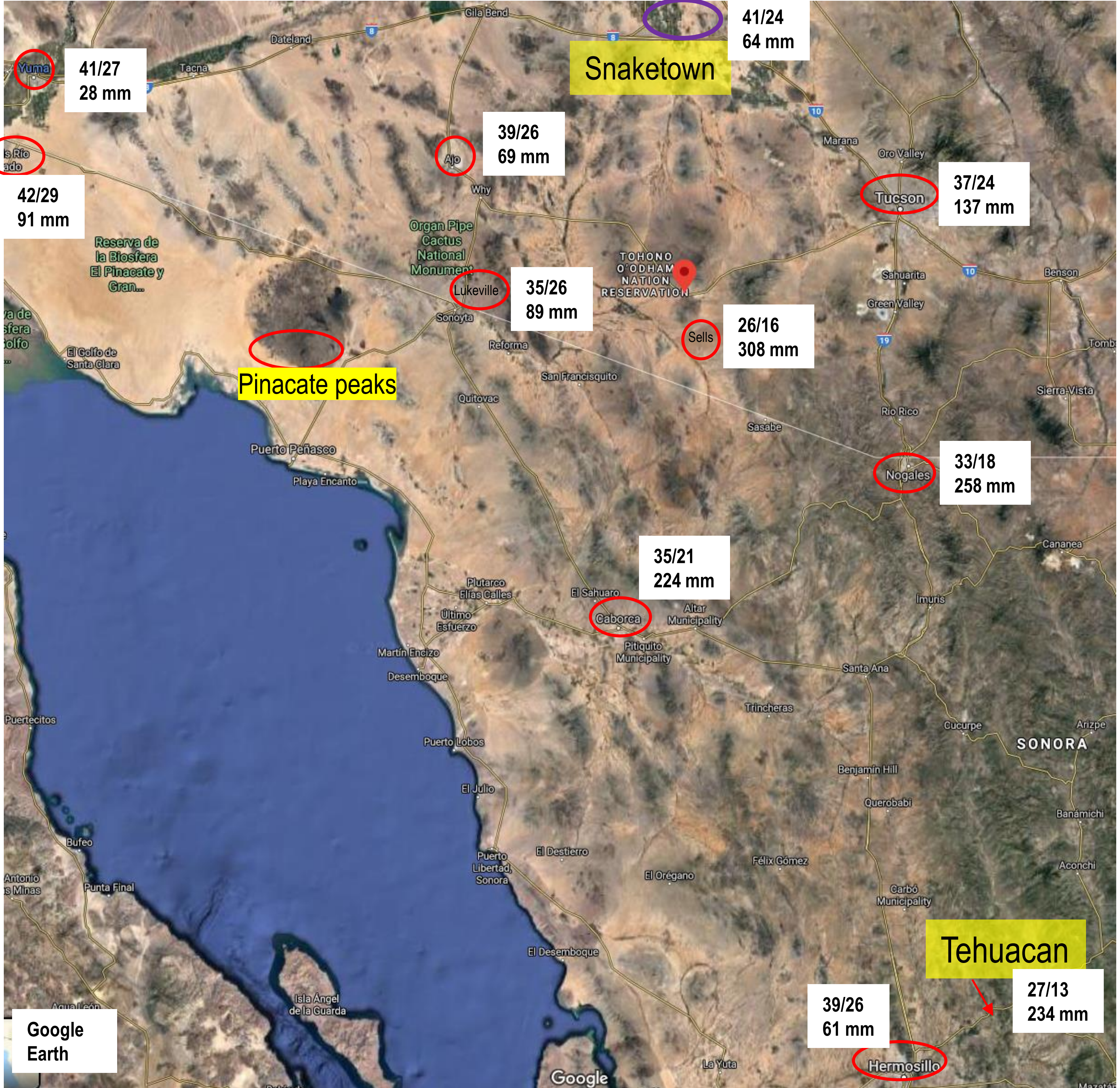
Frankie Coburn

T. Porch (Wilcox, AZ)

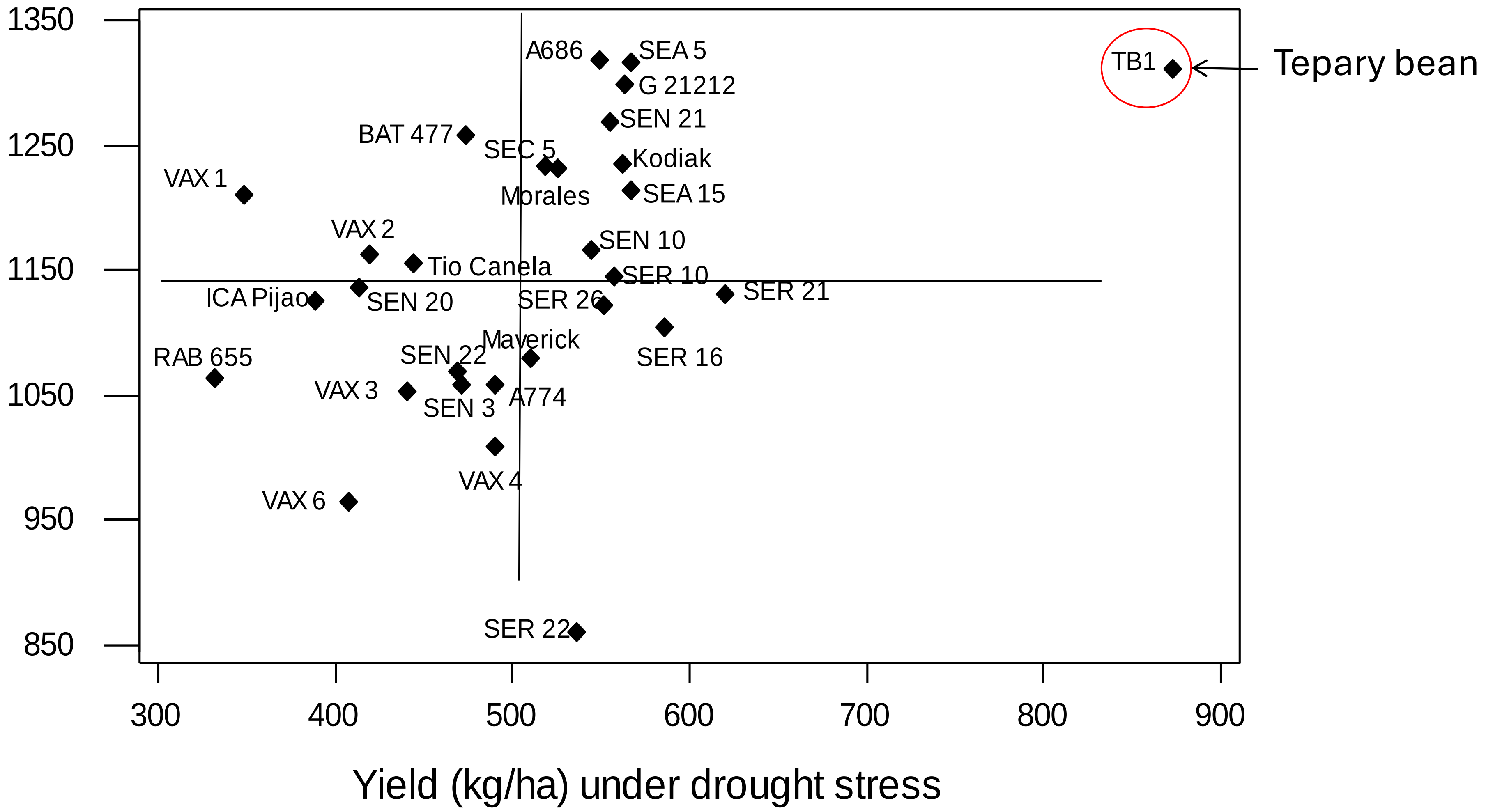
Average August temperature
(Max/Min, C)

Cumulative Precipitation July-Sept
(mm)

-1973 recorded highest temp. of 56.7C (134F) in Sierra Blanca (Felger, 2000)



Drought evaluation of elite beans and a tepary bean

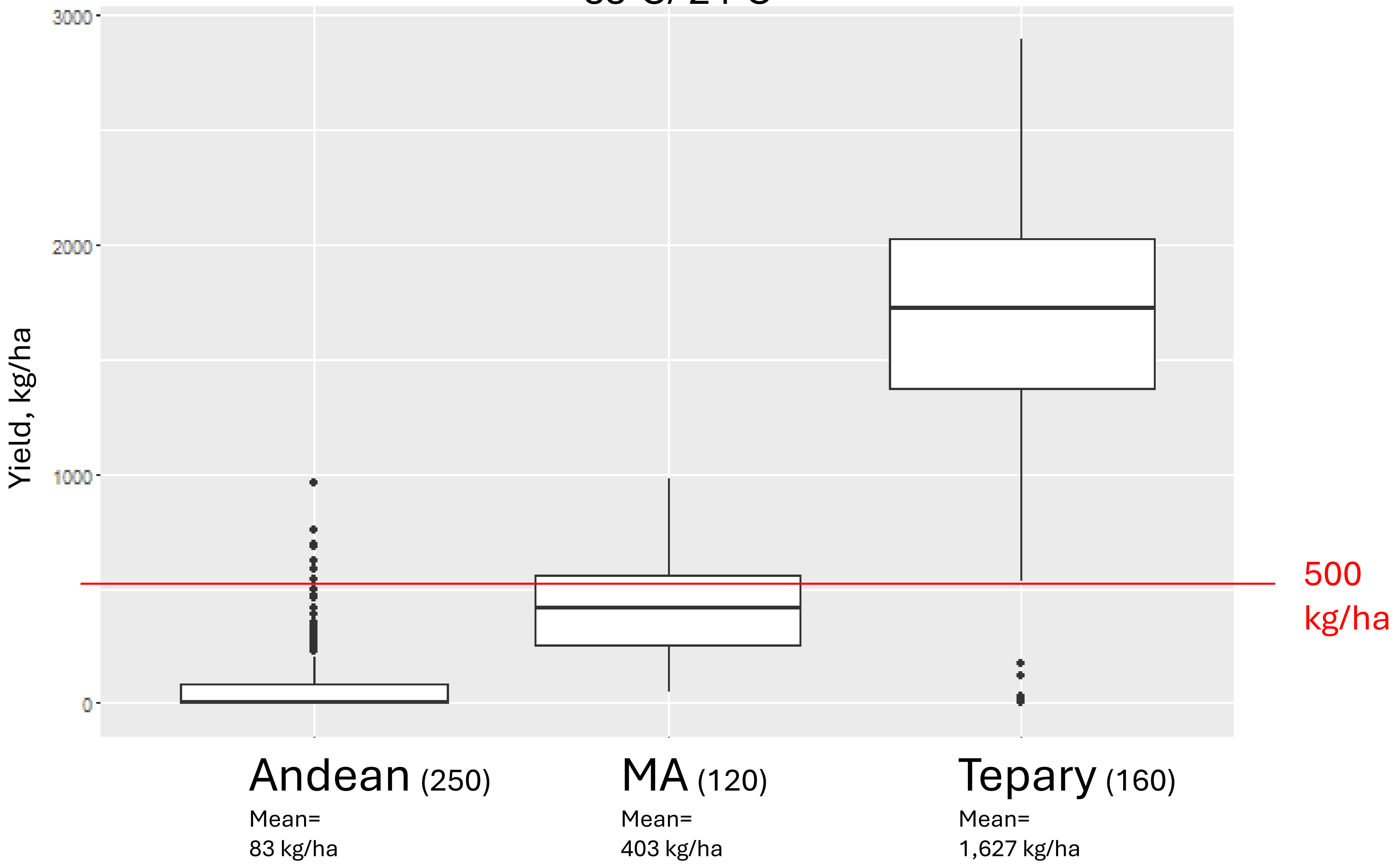


(Porch et al., 2008)

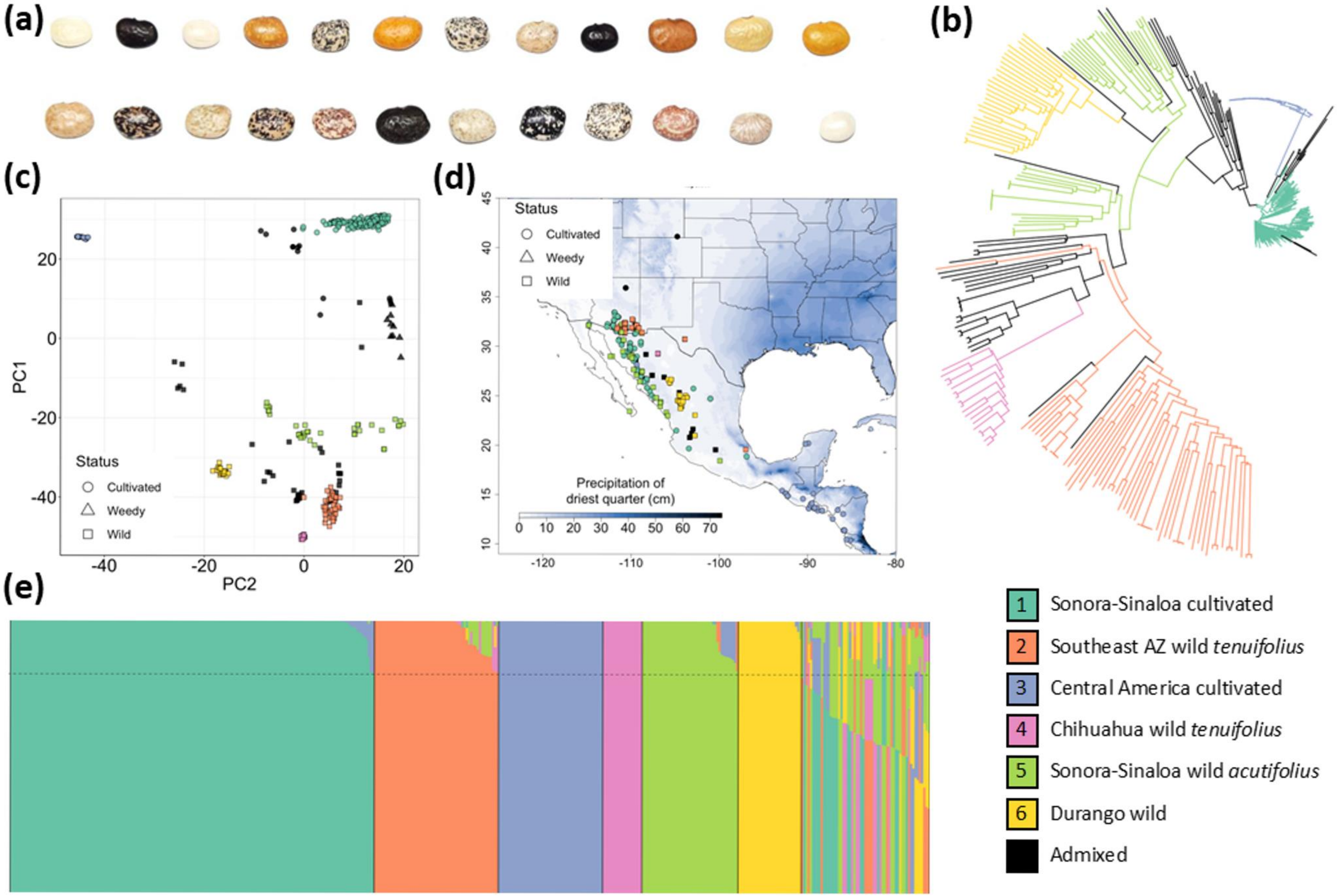
Heat tolerance across *Phaseolus* diversity panels

Juana Diaz, Puerto Rico in 2015

33^{0}C/ 24^{0}C



Tepary Diversity Panel



Germplasm
- 422 Accessions
- CIAT (mostly), GRIN, TARS

Genotyping
- *Ape*KI GBS
- Filtering, and imputation
- LD pruning
- 38,629 SNPs

Bornowski et al. 2023

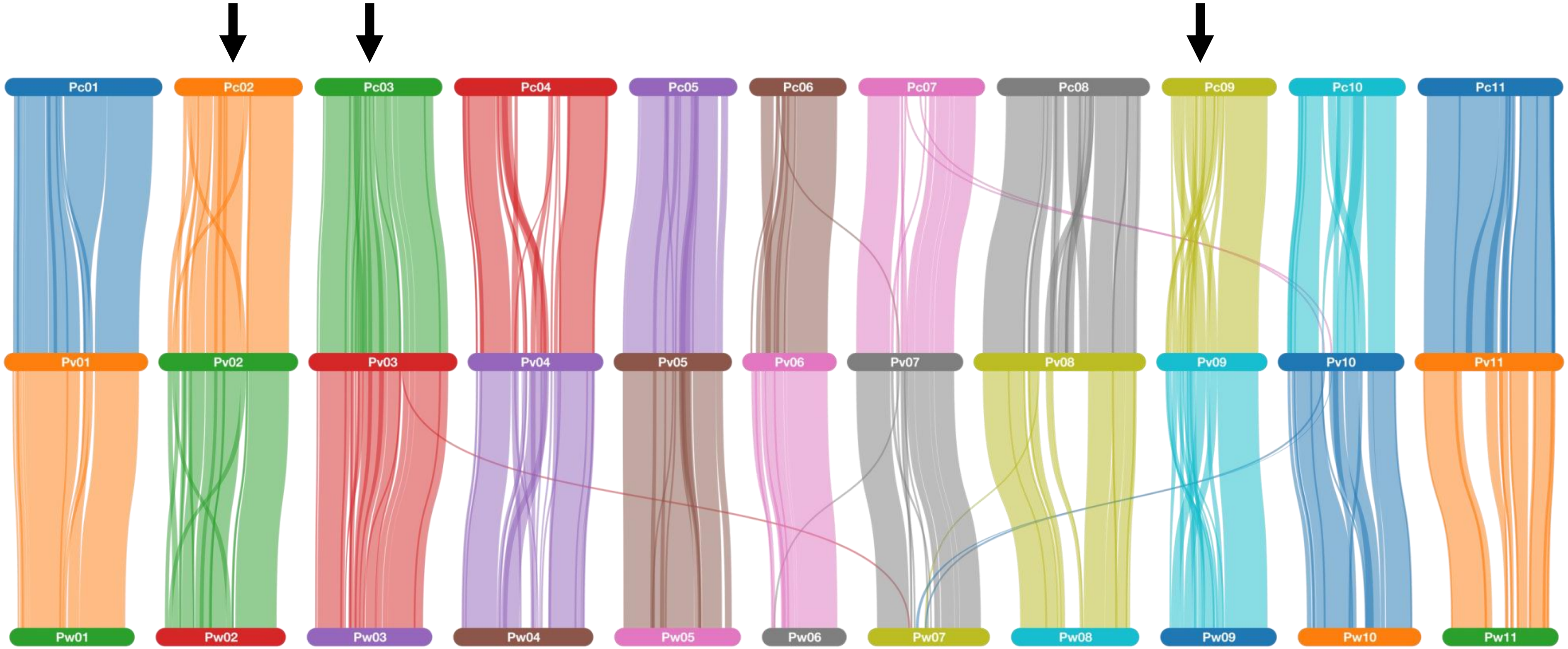
Extensive Synteny between *Phaseolus* species

Previously shown inversions/translocations between Pv & Pa

Fijol Bayo

P. vulgaris (Chaucha chuga)

W6 15578



~90% of Pa genes are syntenic with Pv

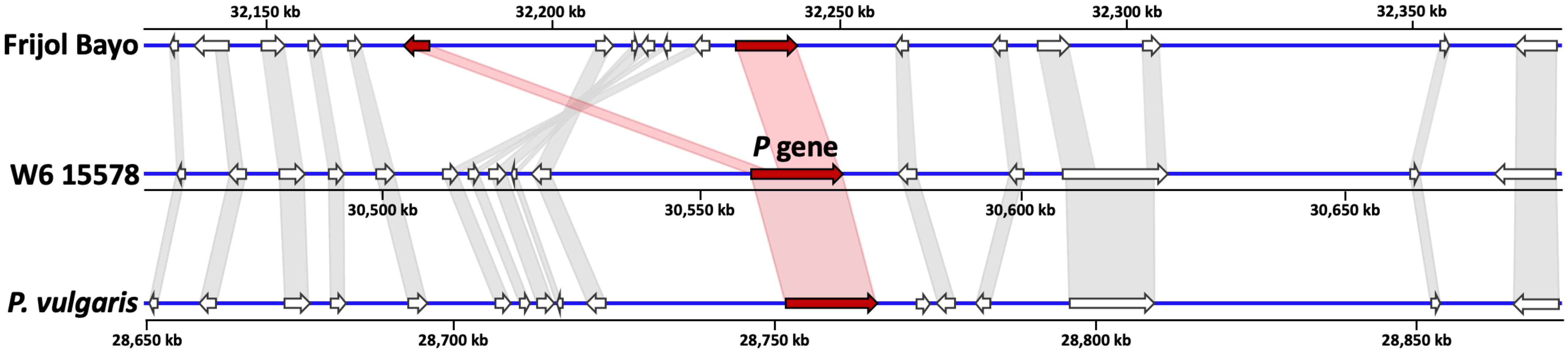
Mafi Moghaddam et al. 2021

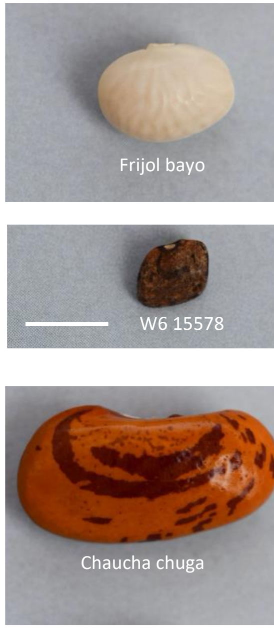
Can we accelerate breeding of both common and tepary bean via leveraging genomic data across *Phaseolus* species?

Andrew Wiersma

- *Phacu.001G234100, a P. acutifolius* homolog of *PvTFL1y,* is 99% identical to the *P. vulgaris* indeterminate allele, providing a target to alter the growth habit of tepary via mutagenesis or gene editing.

- Likewise, white-seed coat color (domestication trait) is associated with an inversion in the *P*-locus in domesticated tepary bean providing a new allele for the P-locus





Mafi Moghaddam et al. 2021

Some breeding objectives for cross-genome improvement

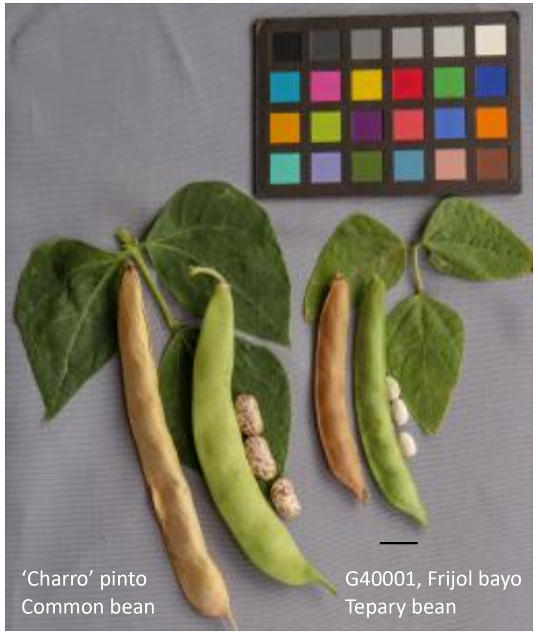
From Common Bean

<u>Agronomic Traits:</u>

Habit
Pod quality
Seed size

<u>Resistance to:</u>

BCMV
BCMNV
BGYMV
Powdery Mildew



Bridging genotypes

From Tepary Bean

<u>Resistance to:</u>

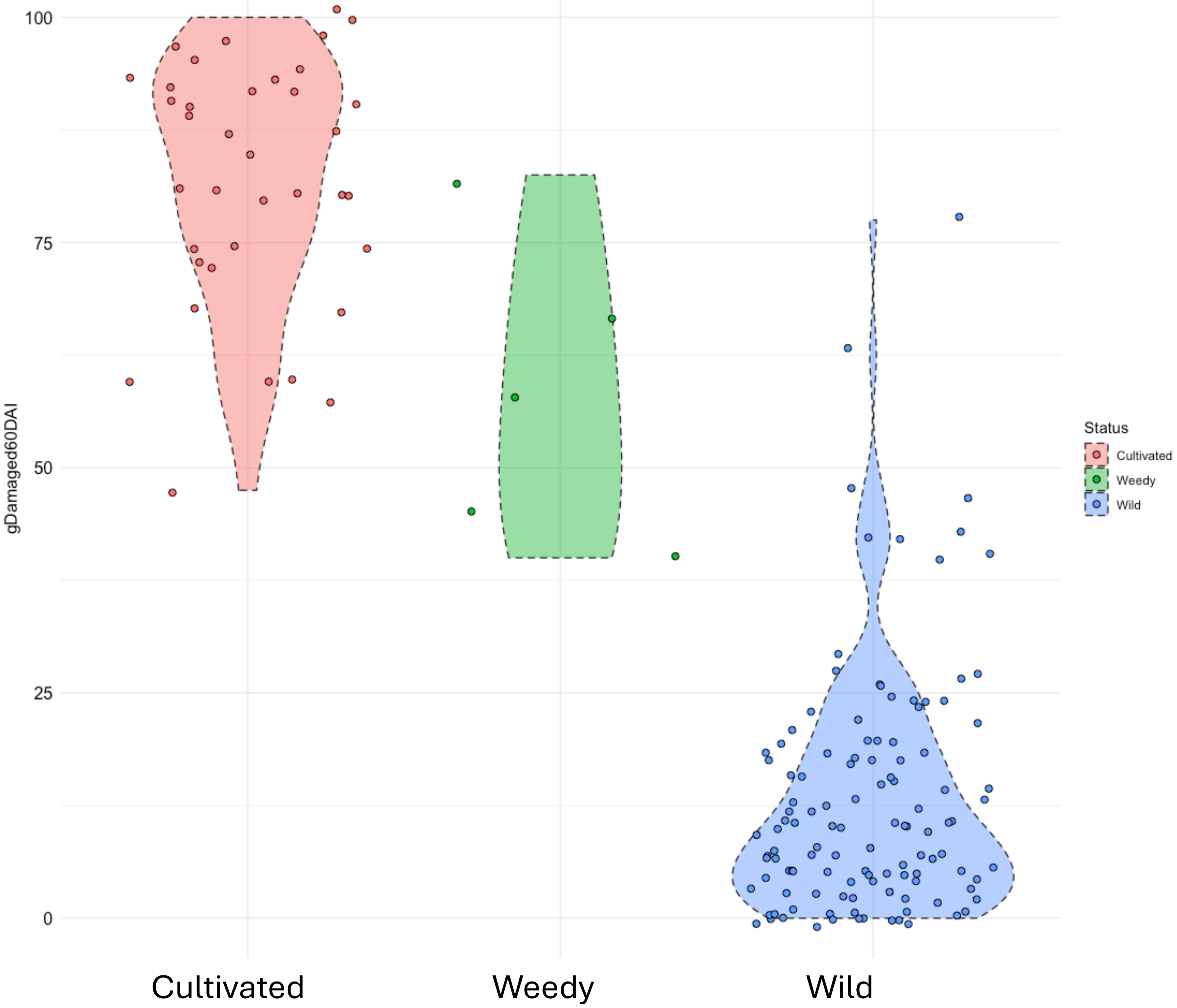
Bacterial blight (CBB)
Rust (immunity)
Bruchid
Leafhopper

<u>Resilience to:</u>

Heat*
Drought*

Bruchid damage after 60 days in TDP

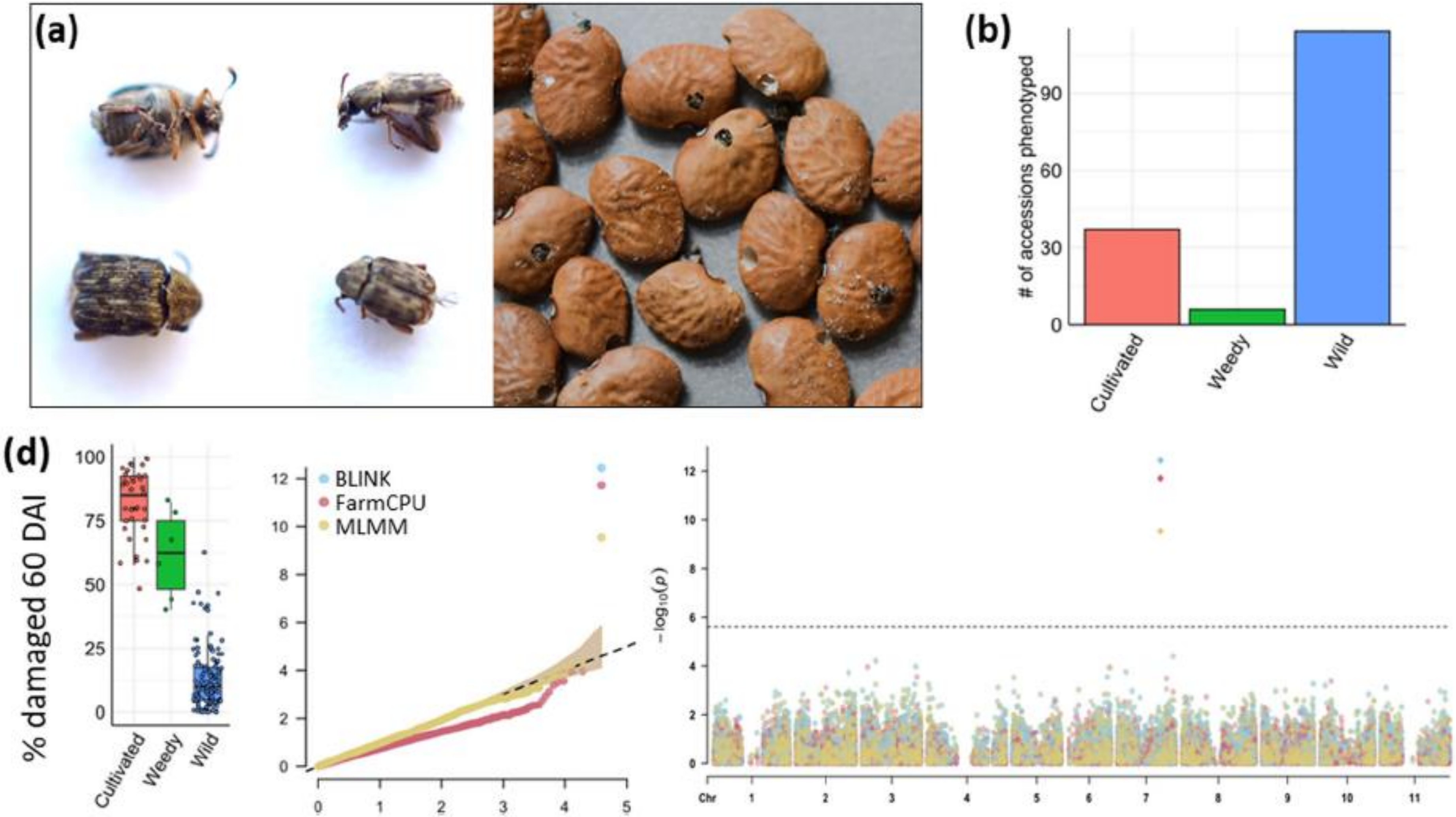
Germplasm
- 157 Accessions
- 114 wild, 37 cultivated, 6 weedy



Response of the TDP and breeding lines infested with the common bean weevil, *Acanthoscelides obtectus* (Porch et al., 2022)

TDP #	Accession and origin	Eval. 1 60 d damaged seeds (%)	Eval. 2 60 d damaged seeds (%)	100 seed weight (g)	% loss of initial weight
61	G40078, Wild, Texas	0	0	2.4	0.2
68	G40087, Wild, Durango, Mexico	0	0	7.1	3.0
173	G40196, Wild, Texas	5	5	6.4	0.0
194	G40214, Wild, Arizona	0	0	4.3	8.1
235	G40253A, Wild, Mexico	0	0	3.3	0.2
334	PI 661753, Wild, Unknown	0	0	1.5	0.0
341	PI 640989, Wild, Arizona	0	0	3.1	0.0
372	PI 310803, Cultivated, Nicaragua	60	90	18.7	57.8
318	Bawi, PI 440799, Cultivated, Arizona	90	90	21.1	53.4
312	TARS-Tep 23, Breeding line	100	45	20.6	40.0
NA	TARS-Tep 90, Breeding line	20	12	22.0	46.4
NA	TARS-Tep 93, Breeding line	20	5	16.6	49.0

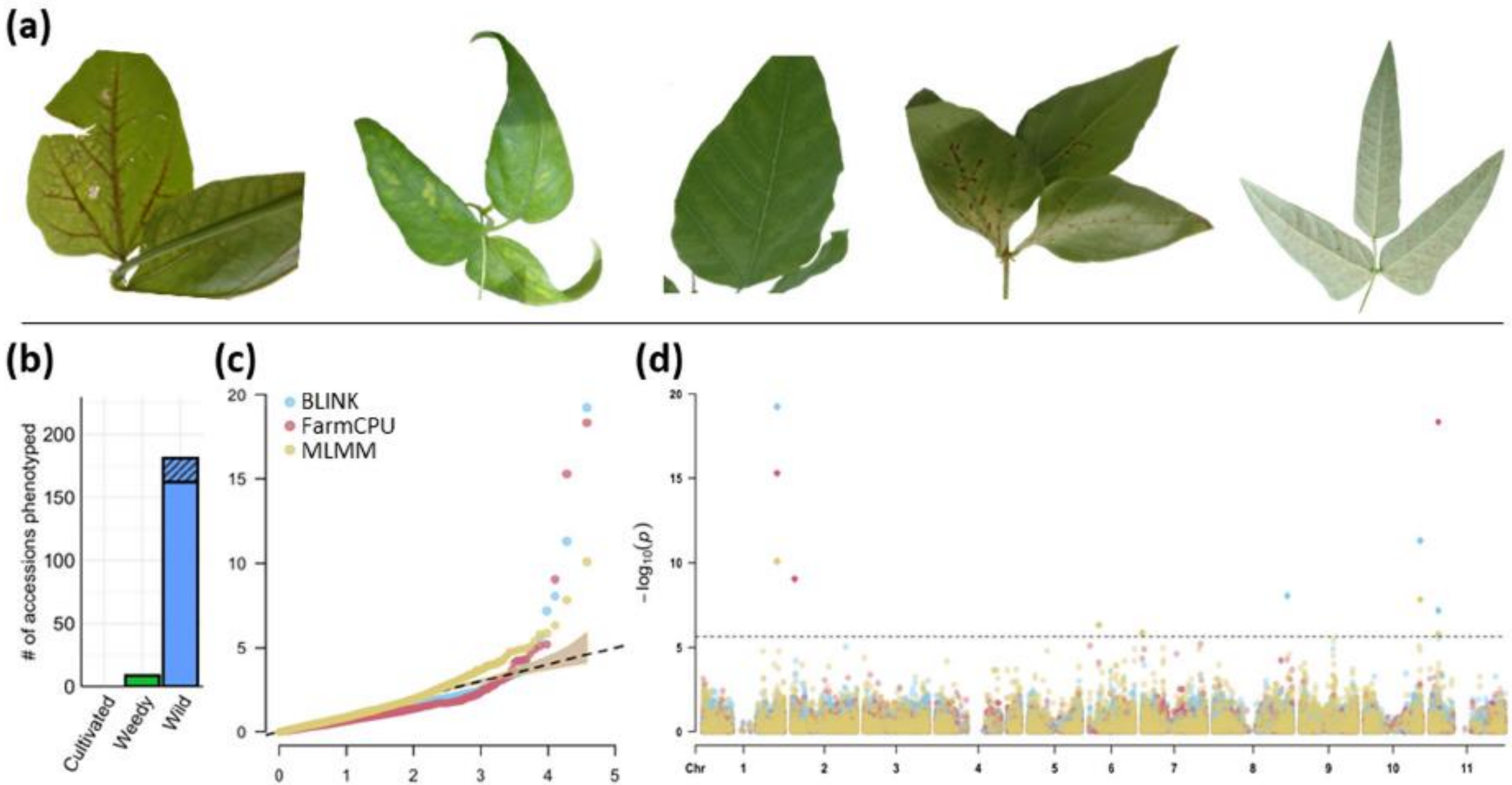
GWAS analysis of bruchid damage at 60 days



(Boronowski, 2023)

BCMNV virus response (NL3 strain)

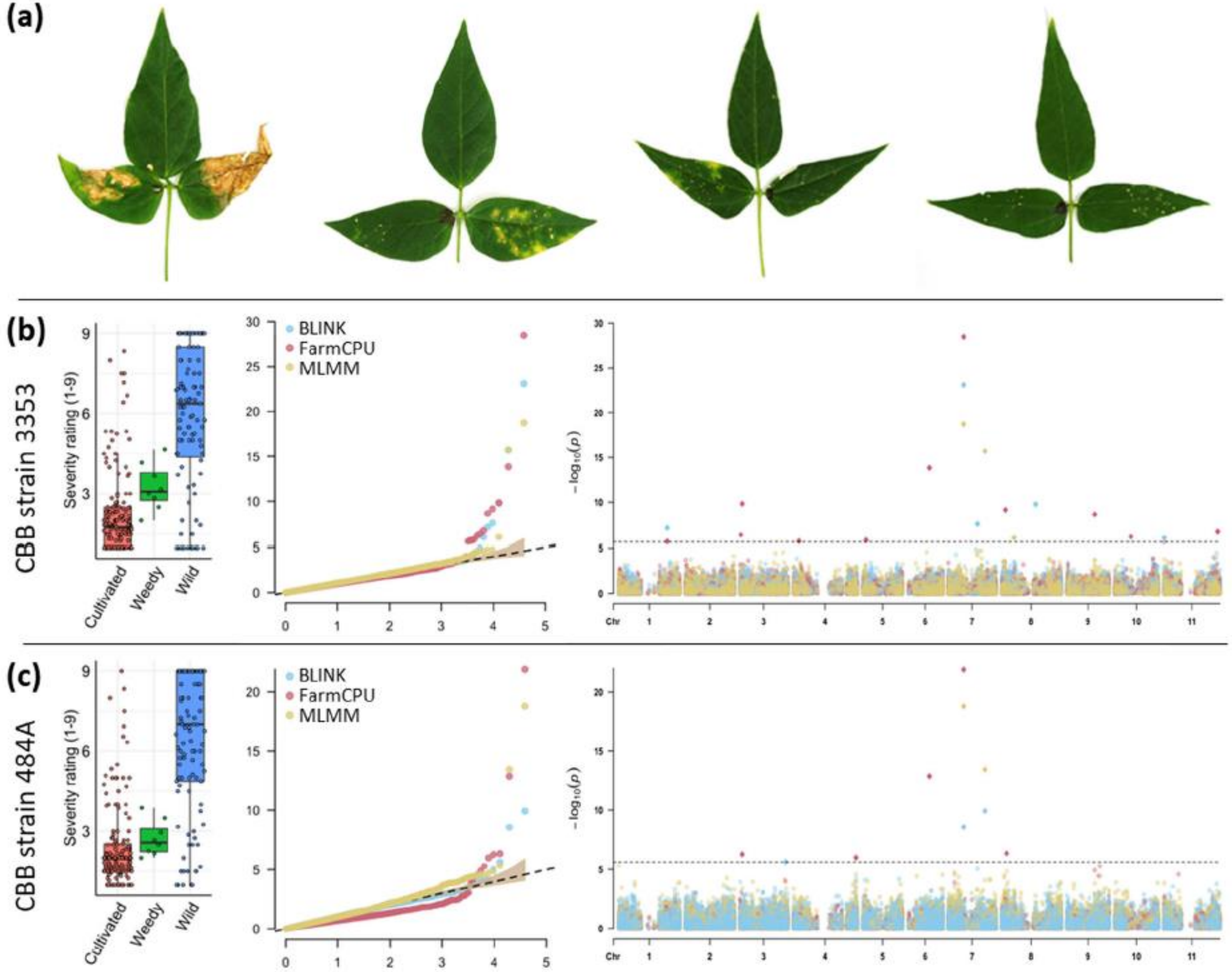
Evaluated
- 190 Accessions
- Inoculated with NL3
- ELISA readings
- Visual scores



Backcross breeding: Release soon

Common bacterial blight

Germplasm evaluated
- 269 Accessions
- Innoculated with 2 strains: 484A, 3353
- Visual readings



Rust

caused by *Uromyces lindemuthianum*

- Highly variable pathogen benefits from cool, humid conditions, long dew periods
- Rust controlled by 13, nine named and four unnamed, resistance genes in common bean, a series: e.g. *Ur-3, Ur-4, Ur-5, Ur-6, Ur-11*
- **Immunity—not existent in common bean**
- Early report showed incomplete dominant resistance in tepary (Miklas and Stavely, 1998)

HortScience 33(1):143–145. 1998.

Incomplete Dominance of Rust Resistance in Tepary Bean

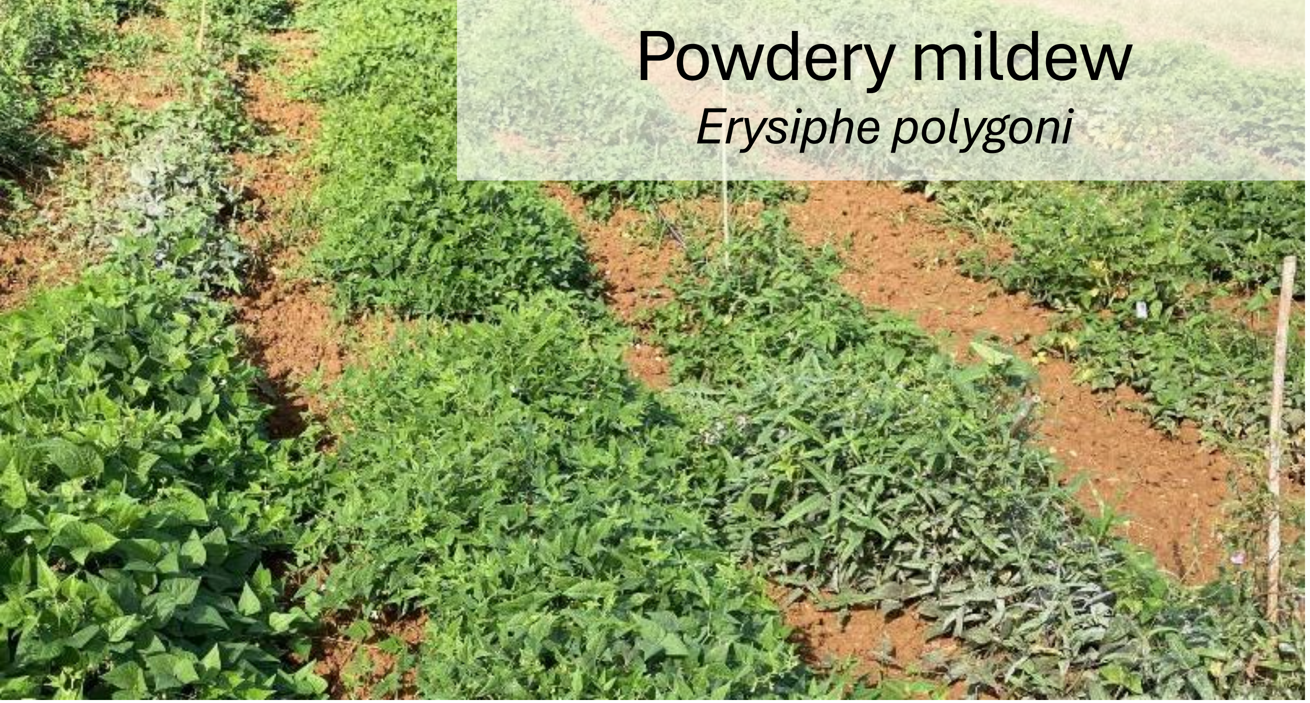
Phillip N. Miklas[1]
U.S. Department of Agriculture, Agricultural Research Ser
Agriculture and Extension Center, 24106 North Bunn R
WA 99350-9687

J. Rennie Stavely[2]

Line	Mesoamerican races						Andean races	
	13-2 (43)	15-3 (47)	22-6 (49)	31-1 (53)	31-22 (67)	22-52 (108)	21-0 (72)	37-1 (84)
TARS-Tep 23		1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)
TARS-Tep 22	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)
TARS-Tep 29	4 (S)	4 (S)	4 (S)	4 (S)	4, 5 (S)	5 (S)	f2/3 (TP)	2, f2 (S)
TARS-Tep 32	4 (S)	4, 5 (S)	4, 5 (S)	4 (S)	5, 4 (S)	5, 4 (S)	4 (S)	3 (S)
G 40001	4, 5, 6 (S)	4, 5 (S)	4, 5 (S)	4, 5 (S)	f2, 3 (TP)	f2, 3 (TP)	f2 (TP)	f2, 3 (TP)
Pinto UI 114 (check)	4, 5 (S)	5, 6 (S)	5, 6 (S)	4, 5 (S)	4, 5 (S)	4, 5 (S)	5,6 (S)	5, 6 (S)

(Talo Pastor Corralles, ARS, Beltsville)

Ongoing biotic studies



Powdery mildew
Erysiphe polygoni

Asian bean flower thrip
Megalurothrips usitasis

Pythium
root rot
Pythium spp.

Adjusted means (BLUPs) for TDP accessions showing resistance to Asian bean flower thrips and Empoasca spp. in Isabela, Puerto Rico in 2023

Line	#TDP	Type	Leaf curl[1]	DTM (days)	Yield (kg/ha)	HSW[2] (g)
G40177A2	149	wild	5.3	63.9	998	10.2
21IS-8799-6	NA	improved	5.9	66.8	926	7.5
G40151	121	cultivated	4.7	74.8	663	11.8
TARS-Tep 23	312	improved	6.3	66.6	650	15.7
G40177A1	148	cultivated	5.2	63.8	594	13.3
G40159	128	cultivated	7.7	77.9	586	11.0
G40192	168	wild	5.5	61.8	558	5.2
TARS-Tep 100	437	improved	6.3	66.5	533	15.6
PI 549447	301	cultivated	6.2	68.5	528	11.6
G40016	373	cultivated	7.6	65.1	527	15.5
G40173B	402	wild	5.6	64.2	513	9.0
TARS-Tep 54	419	improved	6.2	66.0	505	10.1
PI 653254	333	silvestre	4.1	59.2	501	5.7
G40001	1	cultivated check	4.6	70.0	117	11.9
Sacaton white	407	cultivated check	6.5	68.2	281	8.7
BLUP			5.1	69.0	207	7.8

[1]Leaf curl (1 to 9; 1 resistant and 9 susceptible); [2] 100 seed weight.

Breeding objectives

Agronomics

- Yield
- Improved architecture, pod position
- Earliness

Stress tolerance/resistance

- Heat, drought, low soil fertility
- BGYMV, BCMV, CBB, ASB Leafhopper, bruchid, Asian bean flower thrip

Quality

- Larger seed size, rounder shape, solid color
- Reduced cooking time, hard seed

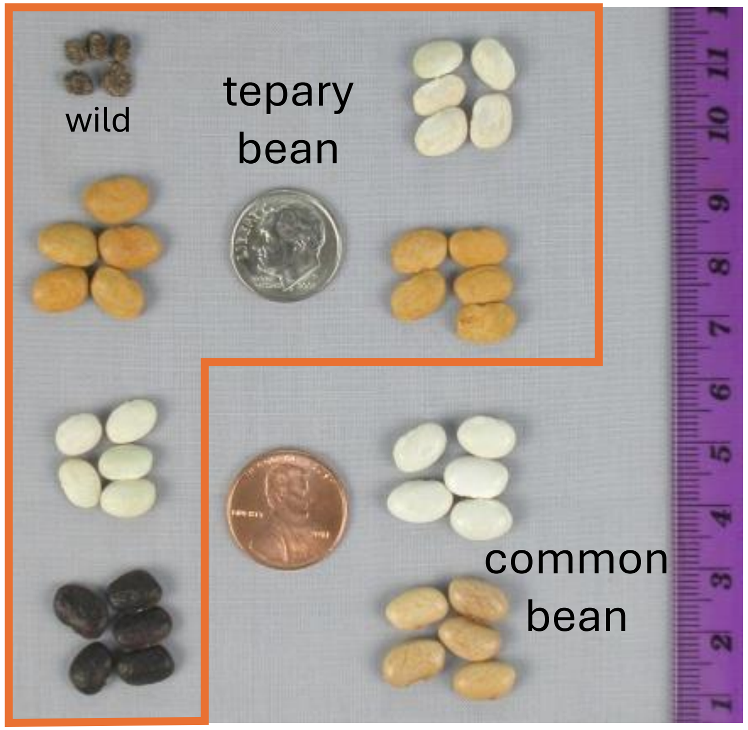
GERMPLASM

Registration of Tepary Germplasm with Multiple-Stress Tolerance, TARS-Tep 22 and TARS-Tep 32

Timothy G. Porch,* James S. Beaver, and Mark A. Brick

ABSTRACT

High ambient temperature and drought stress as a result of climate change are increasingly critical factors affecting agriculture, specifically grain legume production. Tepary bean (*Phaseolus acutifolius* A. Gray), a drought- and heat-tolerant species closely related to common bean (*P. vulgaris* L.), has long been employed by Native Americans for production in regions prone to abiotic stress. In addition to abiotic stress, common bacterial blight [caused by *Xanthomonas axonopodis* pv. *phaseoli* (Smith) Dye] and seed weevils [*Acanthoscelides obtectus* (Say)] are widespread yield and storage constraints worldwide, respectively. TARS-Tep 22 (Reg. No. GP-288, PI 666350) and TARS-Tep 32 (Reg. No. GP-289, PI 666351) were developed by the USDA-ARS, the University of Puerto Rico Agricultural Experiment Station, and Colorado State University. The tepary bean germplasms were selected for multiple stress tolerances, including high-temperature and drought stresses and resistance to bacterial blight and seed weevils, and for larger seed size and more erect architecture. TARS-Tep 22 represents the first published release of improved tepary as a result of hybridization and selection, and TARS-Tep 32 is a single plant selection from a landrace (PI 477033) from Arizona. The use of this improved germplasm by farmers in production zones affected by abiotic and/or biotic stress or by breeding programs can potentially increase yields of this newly rediscovered crop.



Received: 25 April 2021 | Accepted: 28 July 2021 | Published online: 21 October 2021

DOI: 10.1002/plr2.20180

Journal of Plant Registrations

REGISTRATION

Germplasm

Release of tepary bean TARS-Tep 23 germplasm with broad abiotic stress tolerance and rust and common bacterial blight resistance

Timothy Porch[1] | Santos Barrera[2] | Jorge C. Berny Mier y Teran[3] | Jairo Díaz-Ramírez[4] | Marcial Pastor-Corrales[5] | Paul Gepts[3] | Carlos A. Urrea[2] | Juan Carlos Rosas[6]

TARS-Tep 23

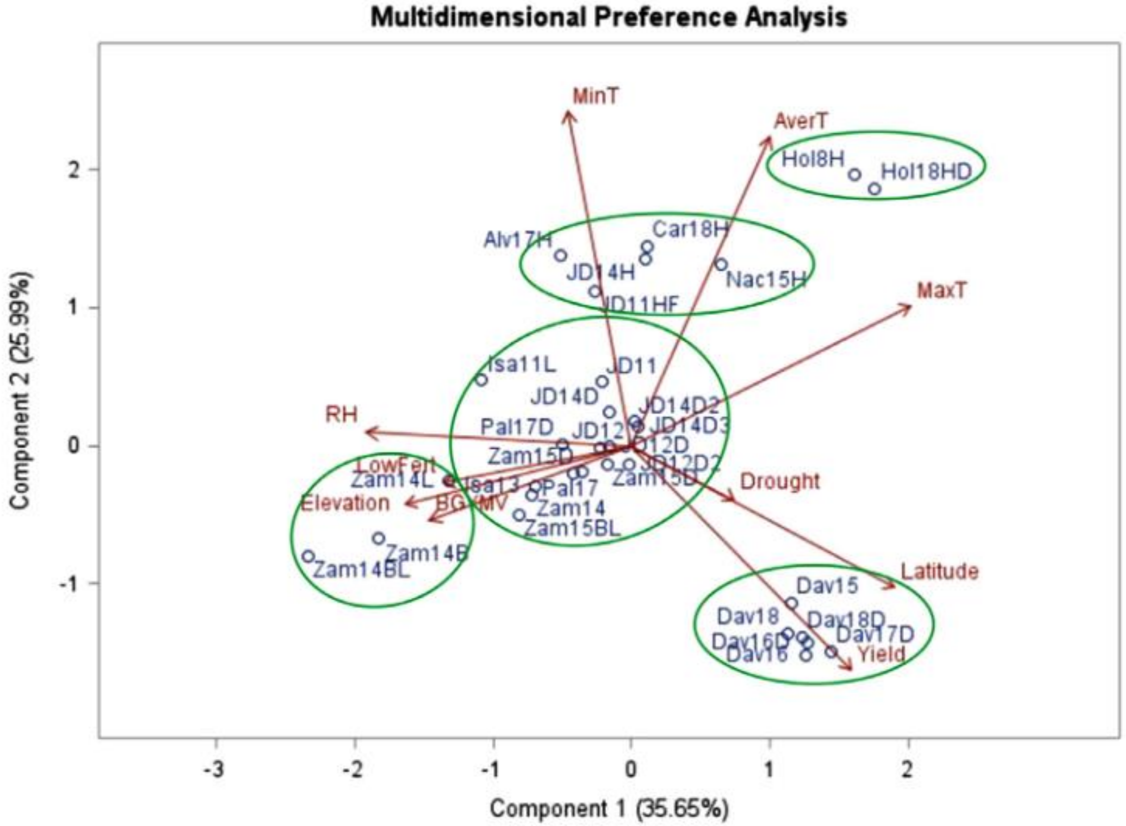


FIGURE 2 Uncooked (left) and cooked (right) seed of TARS-Tep 23. The cooked seed was soaked for 12 h and then cooked for 1 h, both in distilled water. The line represents 1 cm

‘USDA Fortuna’

- Improved seed size
- Fast cooking time
- No hard seed
- Resistance to leafhopper, common bacterial blight
- Tolerance to Bean golden yellow mosaic virus

DOI: 10.1002/plr2.20322

Journal of Plant Registrations

REGISTRATION

Cultivar

Release of tepary bean cultivar ‘USDA Fortuna’ with improved disease and insect resistance, seed size, and culinary quality

Timothy G. Porch[1] | Juan Carlos Rosas[2] | Karen Cichy[3] | Graciela Godoy Lutz[4] | Iveth Rodriguez[5] | Raphael W. Colbert[6,†] | Gasner Demosthene[7] | Juan Carlos Hernández[8] | Donna M. Winham[9] | James S. Beaver[10]

Improving seed quality in multiple disease resistant white tepary beans

HSW=14.4g

HSW=13.6g

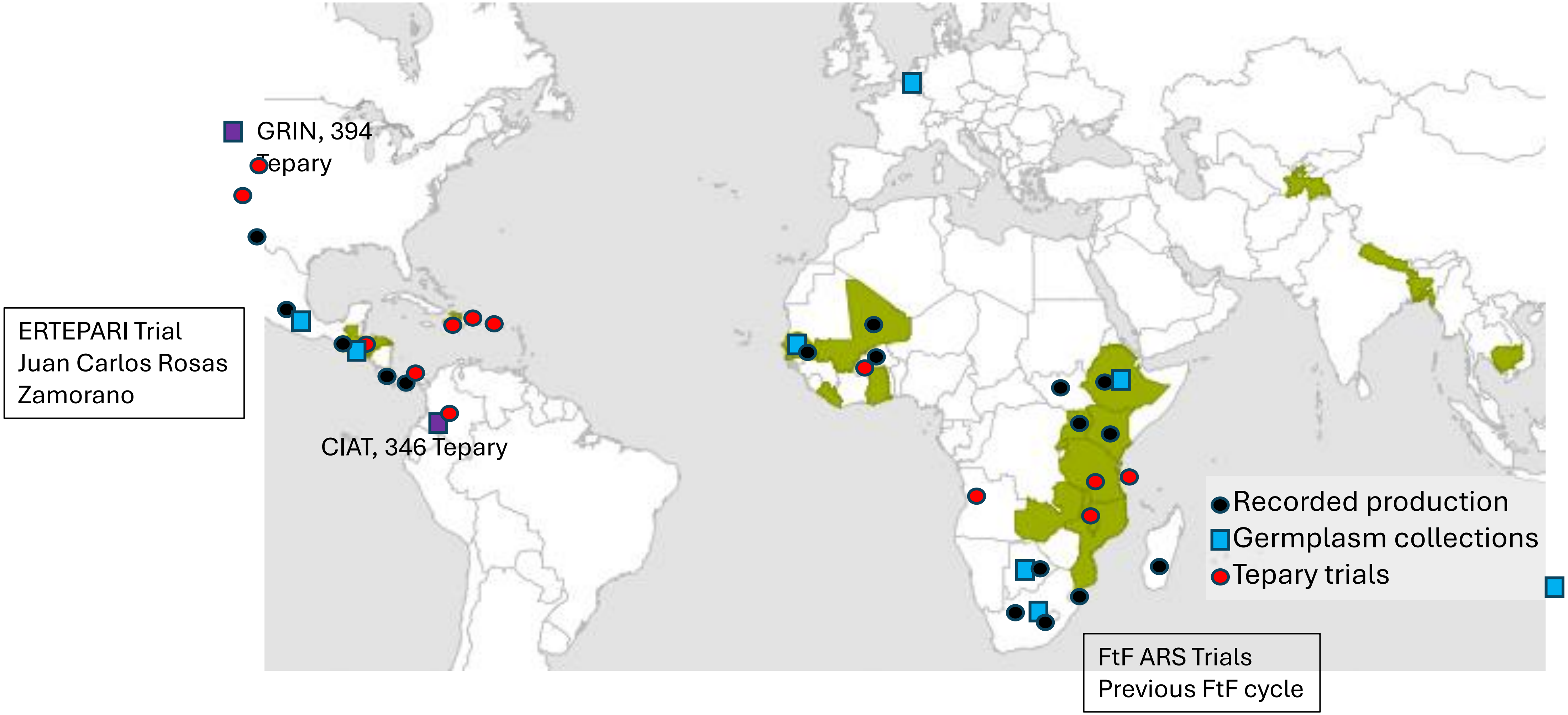
HSW=12.4g
Control

HSW=14

UC Davis—Travis Parker
Good performance

HSW=12.3g
Control

Tepary dissemination



Conclusions

Tepary, a promising future

- Crop in its own right
- Source of traits for common bean

Reception/adoption of improved tepary bean

- Interest in small seed company in U.S.; Other countries; Granting agencies
- Needed: Cultivars with consumer-driven traits, and improved agronomic performance

Collaborative breeding

- Bulk breeding populations
- Regional nurseries

Tanzania common bean release and description

'Kikatiti'
Pinto bean
2024
(I, bc-3
Rust, Drought,
large seed)

Title: Release of 'Kikatiti' a high performing multiple disease resistant pinto cultivar for Tanzania identified from evaluation of the Durango Diversity Panel

Author

- NCHIMBI-MSOLLA, SUSAN - Sokoine University Of Agriculture
- URREA, CARLOS - University Of Nebraska
- KILANGO, MICHAEL - Agricultural Research Institute - Naliendele
- SOLER-GARZON, ALVARO - Washington State University
- Porch, Timothy - *Tim*
- Miklas, Phillip - *Phil*

Description of Baetao-Manteiga 41 and 'Yunguilla' superior Andean common beans for Tanzanian production environments

Article · July 2020
DOI: 10.1002/plr2.20072

- (2020): Rust, ALS, moderate CBB resistance

Home | Job Postings, Announcements | Committees | Articles | *Research* | Reports | Membership | Meetings | Awards | Genetics

Research Techniques

This web page was developed to provide a review of techniques that are widely accepted and have been successfully used to breed common beans for resistance to biotic and abiotic stress. The goal is to provide an overview of appropriate techniques for breeding common beans for a particular trait and to cite references where researchers, graduate students or technicians can obtain more detailed information. We have also included more general information concerning the evaluation of common beans for the benefit of those who are new to the bean research community. Finally, we identified cultivars and breeding lines that can be used as sources of resistance for particular stresses.

- Angular Leaf Spot
- Anthracnose
- Ashy Stem Blight
- Bacterial Wilt
- BCMV and BCMNV
- Bean Breeding Scales
- Bean Golden Yellow Mosaic
- Bean Processing
- Bean Root Rots
- Brazilian Beans
- Bruchid Insect Breeding (English)
- Bruchid Insect Breeding (Spanish)
- Climbing Bean Production Manual – Spanish
- Color Scales
- Common Bacterial Blight
- Coop Dry Bean Nursery 2010
- Drought Stress
- Fusarium Wilt
- Halo Blight
- Rust
- Snap Bean Traits for Processing
- Web Blight

Bean Improvement Cooperative

www.bic.uprm.edu

- Worldwide research community
- Annual Report with membership
- 2-year membership is $40
- Conferences every 2 years
- 2025, Beginning of November

  -Lincoln Nebraska

Collaborators

USDA-ARS

- TARS Bean Team
- Karen Cichy, Talo Pastor-Corrales

University of Puerto Rico

- James Beaver, Consuelo Estevez

University of Georgia—Robin Buell

Michigan State University

- Nolan Boronowski, Andrew Wiersma, Ali Soltani, David Lowry

Zamorano University—Juan Carlos Rosas

North Dakota State U.—Phil McClean, S. Mafi Moghaddam

University of California, Davis

- Paul Gepts, Travis Parker

CIAT Bean Program

FtF Grain Legume Collaborators

- Deidre Fourie, Susan Nchimbi, Emmanuel Prophete, Graciela Godoy

USDA ars

FEED THE FUTURE
The U.S. Government's Global Hunger and Food Security Initiative

Legume Innovation Lab

USAID FROM THE AMERICAN PEOPLE

USDA NIFA