

Participatory Chestnut Breeding

Characterizing Genetic Diversity and Ancestry of Superior On-farm Germplasm

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The Center's Chestnut Improvement Activities

To-date

1. Cultivar conservation and maintenance
2. Cultivar evaluation
3. OP seed and scion distribution

New

1. On-farm evaluation
2. Core collection assembly
3. In situ conservation
4. Systematic, participatory breeding



Repository Maintenance

- “Refreshing” the UMCA repository (65 cvs.)
- Propagating the collection to ensure a sufficient number of healthy ramets
 - 400 grafts made in 2021, ~80% rate
- New entries (17) from G. Miller, M. Nave, and T. Wahl:

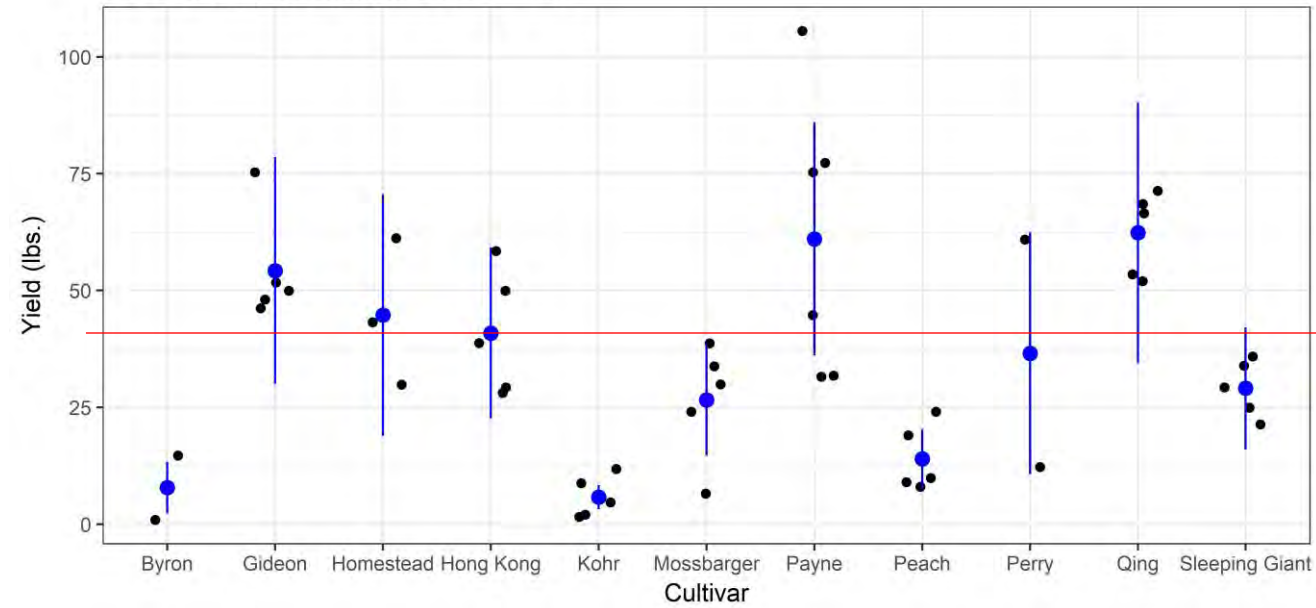
‘Ace’, ‘Bergantz’, ‘Beth’, ‘Chandler’, ‘Emalyn’s Purple’, ‘Hansen’, ‘Kyoung’, ‘Nanjing Special’, ‘Nanking’, ‘Liu’, ‘Patterson’, ‘QingSu’, ‘Red Shed’, ‘Scharlbaum’, ‘Vancouver’, ‘WC’.



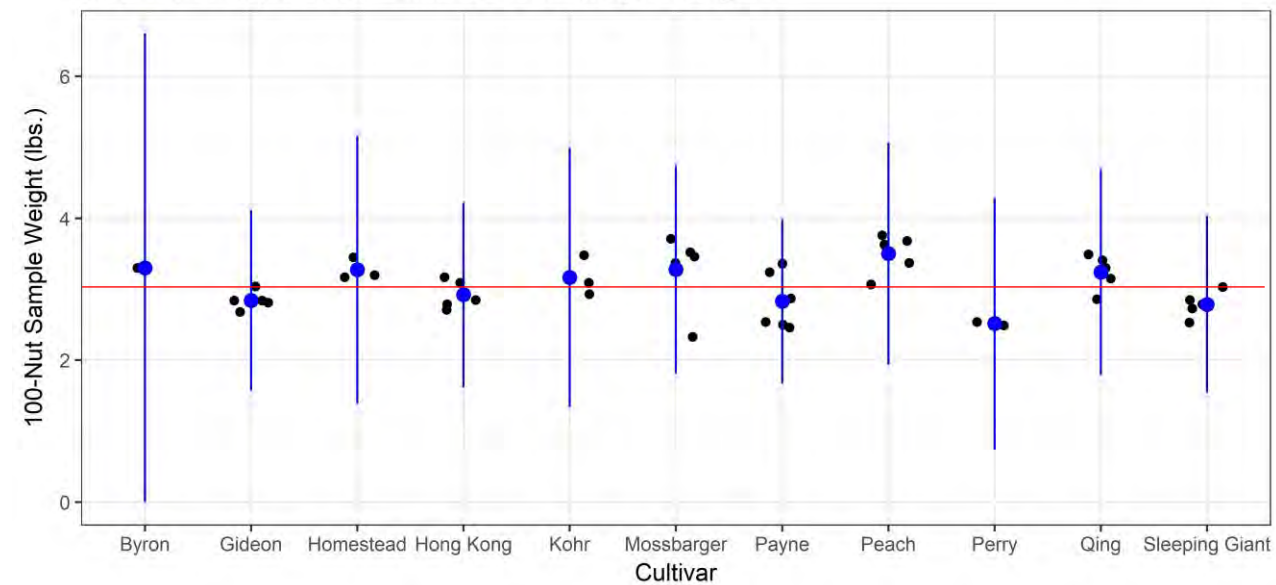
Cultivar Trials Ongoing



2019 Chestnut Cultivar Trial Yields



2019 Chestnut Cultivar Trial 100-Nut Sample Weights

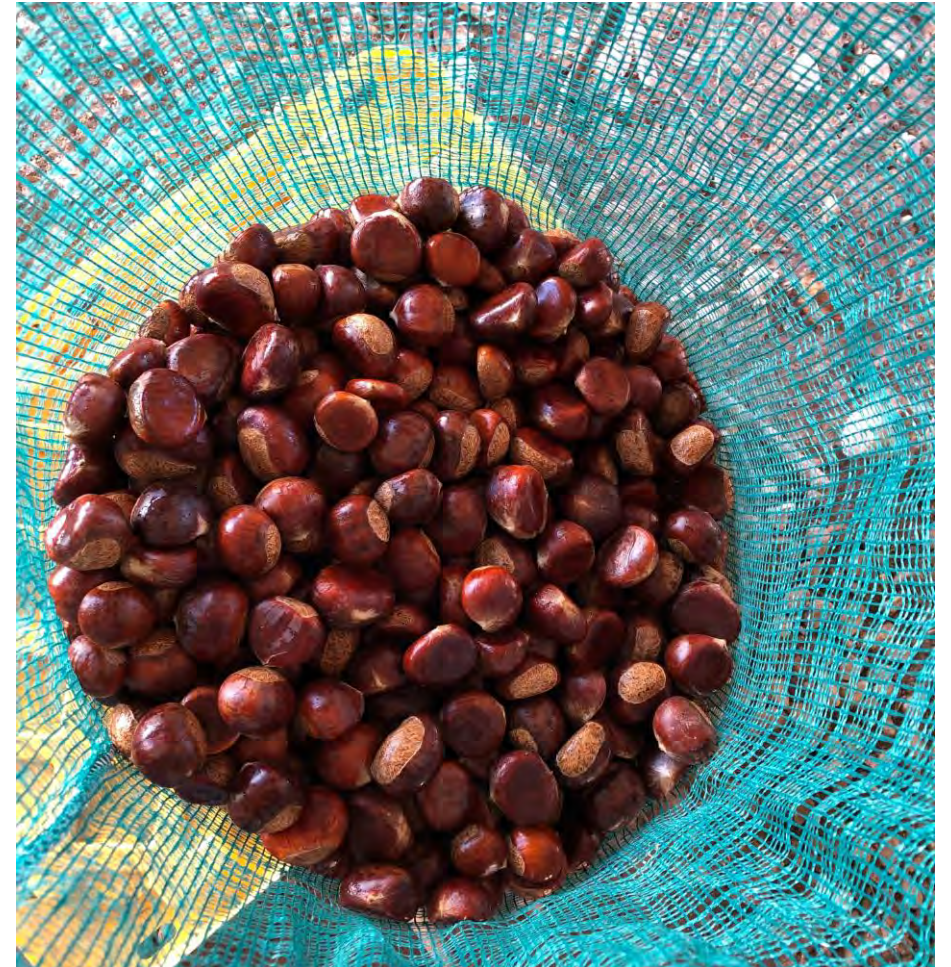


Open-pollinated Seed Distribution

- Four classes of OP seed provided since 2008:
 - Specific cultivars
 - Bulk from 'Peach' × 'Qing' × Kohr' orchard
 - Bulk from the repository (all cultivars)

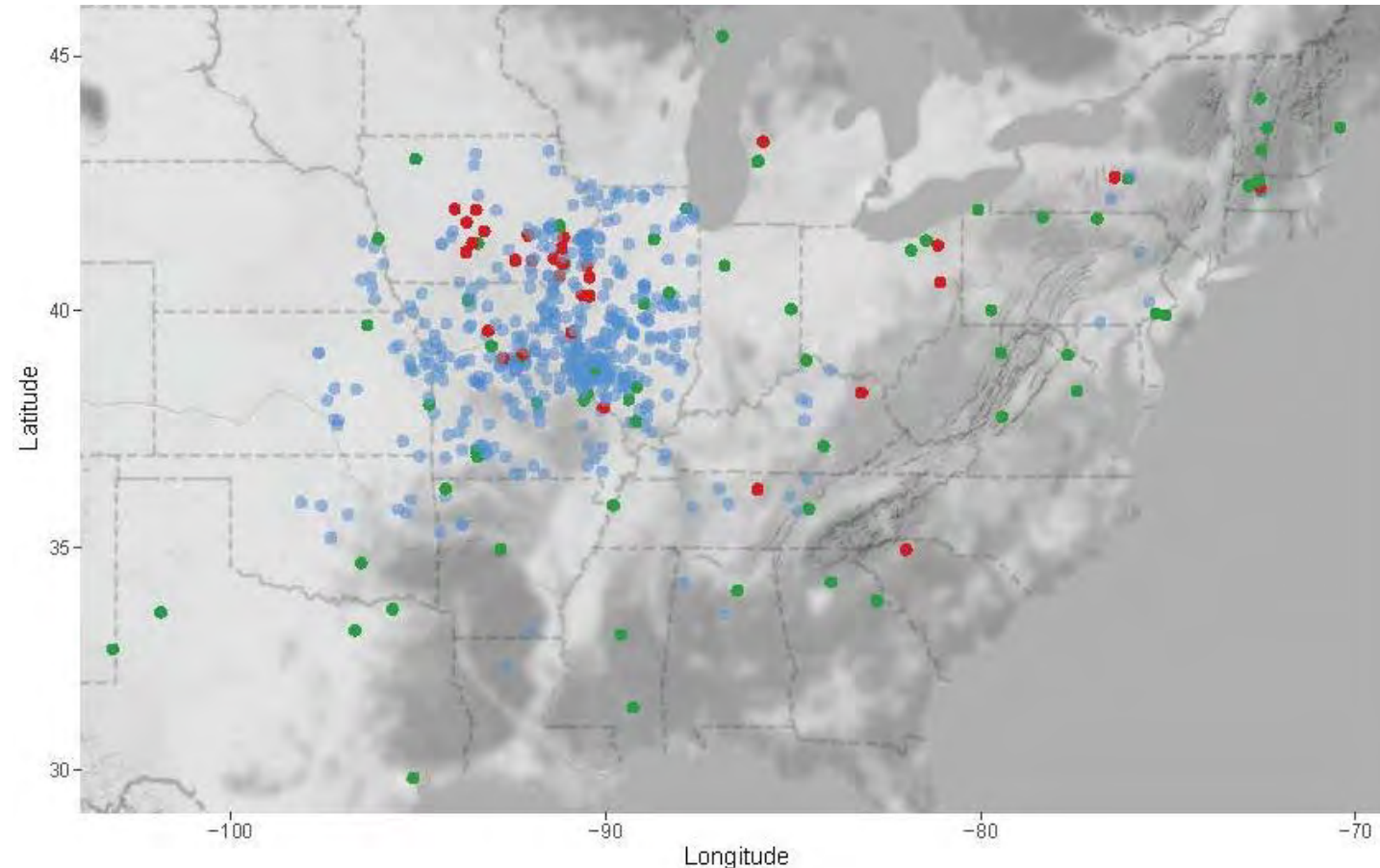
In 2020,

- >1,600 lbs of OP seed shipped to 70 indivs.
- >1,400 lbs shipped to three nursery partners
- The 2021 UMCA order form is improved and will soon be published.



Open-pollinated Seed Distribution

- Over 1,000 growers have received seed from the UMCA directly or through nursery partners
- A massive pre-breeding resource for diverse environments
- **How to best build on these materials?**



Coordinated Evaluation & Breeding

- Why participatory?
 - The sum is greater than the parts.

“Chestnuts are grown over a wide geographic and climatic range in the USA. We are still discovering the adaptation limits of available chestnut material. [...] we are a long way from finding and knowing what is both best adapted and best performing in the various regions. Major components of yield and nut quality are probably independent of regional adaptation.” G. Miller, NNGA 2017.

- A major takeaway is the need for core collection assembly of on-farm selections

“a limited set of accessions representing the genetic diversity with minimum of repetitiveness (Frankel 1984).”

Breeding Chestnuts for Nut Quality and Yield in Eastern North America A Cooperative Breeding Program

*Greg Miller, Route 9 Cooperative,
Carrollton Ohio* NNGA 2017

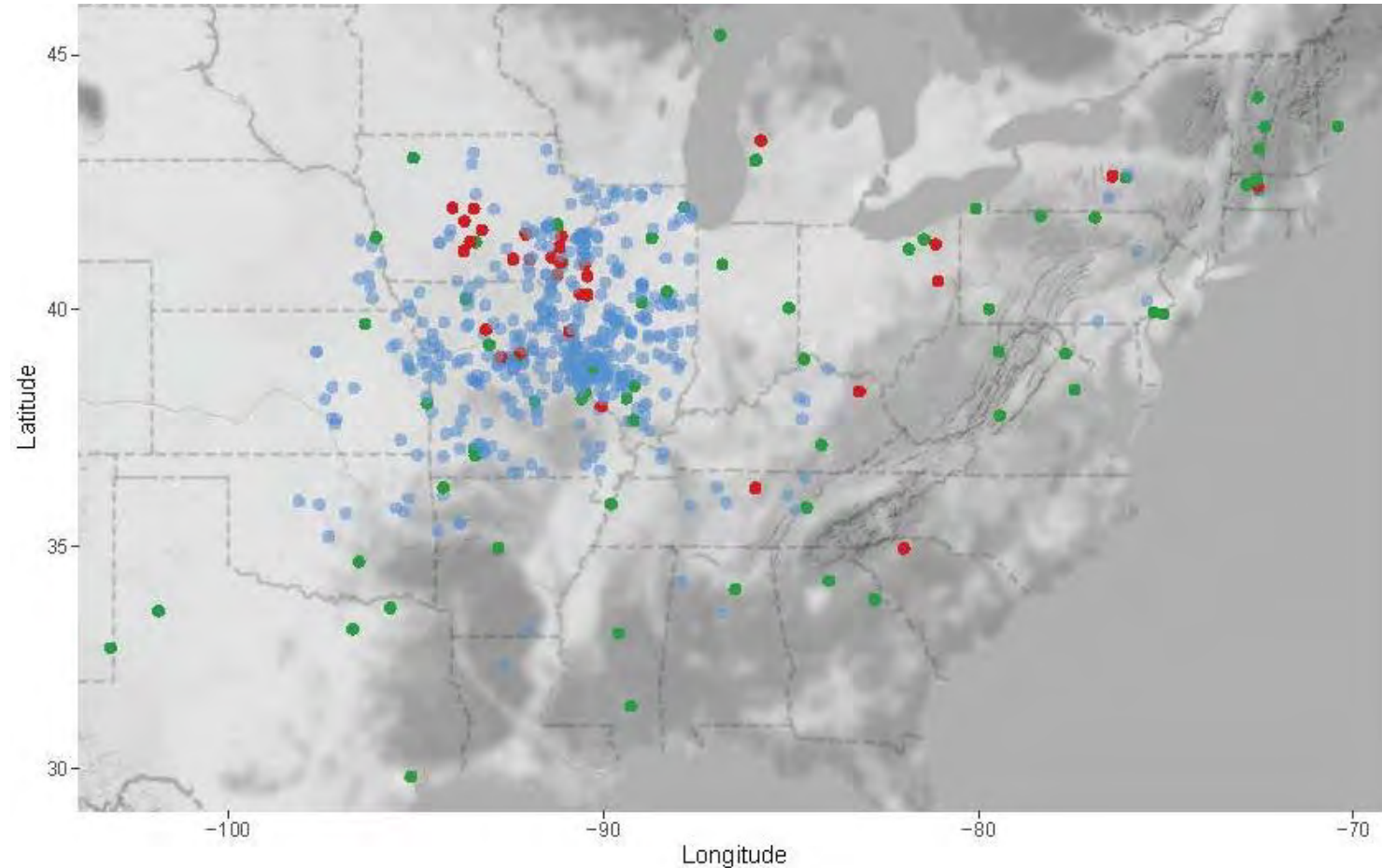


Cooperative Chestnut Breeding in the USA

Greg Miller
Empire Chestnut Company
Route 9 Cooperative

USDA-AMS Grant Overview

- Awarded a USDA-AMS grant of \$923k in 2020 to carry out systematic on-farm evaluations
 - i. Formalize a participant network as a new breeding initiative
 - ii. Characterize genetic diversity in on-farm selections' traits of interest
 - iii. Use EST-SSRs to discern on-farm selections' ancestry & parentage
 - iv. Utilize data from ii. & iii. to construct core collections for conservation and breeding



Core Collection Assembly Assumptions/Goals

- Seedling composition on-farm
- Evaluation 5-8% of growers' "best" trees (600-1,000 trees)
- Grower observations can guide evaluations to these "best" trees
- "Best" defined as:
 - Stable interannual yield
 - Low nut quality defects
 - Unique recombinants
 - e.g., male sterility w/ high kernel quality
- Identify a subset (~10%) to be conserved as a core collection

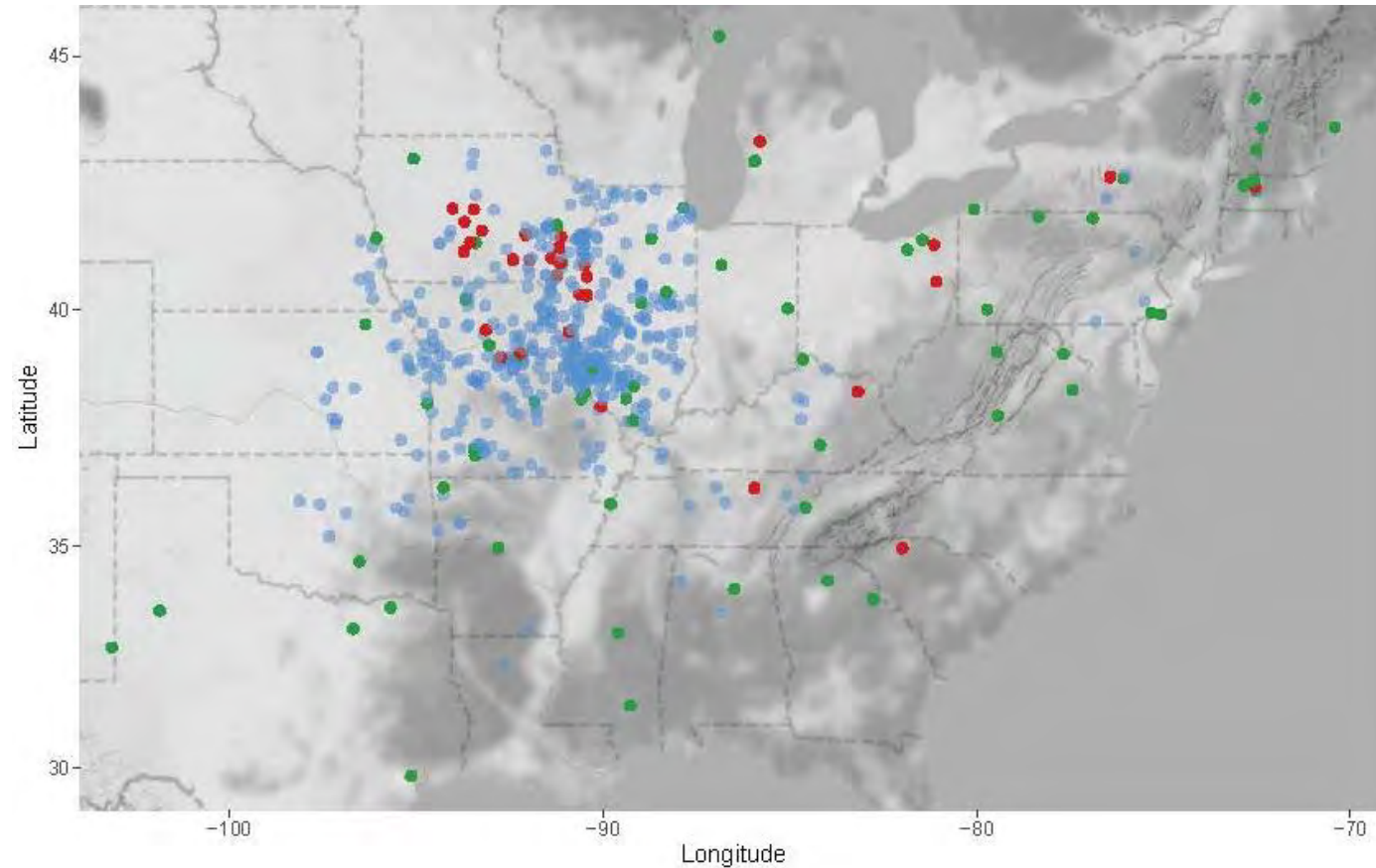
Numbers of Trees Planted per Family

Szego	781	B71	426
Luv Monster	874	72-76	106
Ace	836	Dunstan	20
Kintzel	420	Jers Gem	90
Liu	890	PQK	300
Peach	976	Perry	120
Qing	1024	Payne	120
Kohr	1124	Yixian	120
Gideon	1049	Wynn Mill	10
Sleeping		Hong	
Giant	909	Kong	380
AU-Home	730	Chandler	10
AU-Super	280	B68	130
B65	416	Damiano	430

23 Families
3 Populations
12,571 Individuals

Participants

- 12 growers representing 5 states in 2020 (287 trees)
- 30 growers (red) across 11 states in 2021
 - delayed due to the 2020 frost
 - Expect >600 trees



Please contact us if you'd like to participate

- Email J. Bryan Webber (jbwebber@missouri.edu) and myself (r.revord@missouri.edu)
- What's needed:
 - 30-nut sample per tree
 - Twig tissue for genotyping
 - Dialogue on which trees to include and why
- Commitments beyond the above are not needed at this time; there is no obligation to provide seed, scion, or pollen.

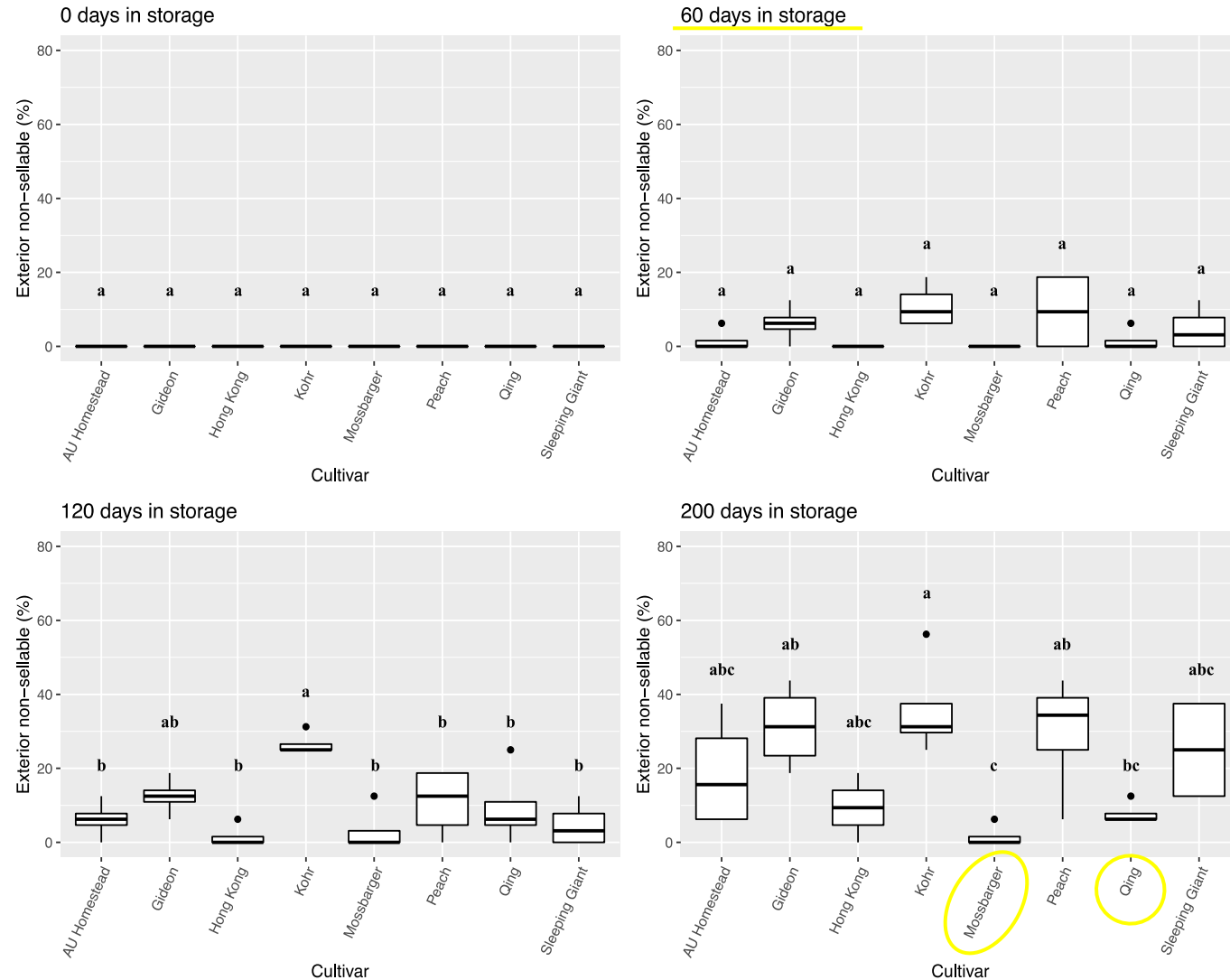
Phenotyping

- Field traits (7)
 - Architectural characters
 - Yield estimate
 - Fruiting-pattern
- Nut and kernel quality (16)
 - Size, Shape
 - Color, Texture, Taste
 - Pellicle removal, embryo#
 - Weevil/spoilage resistant
- Leaf morphologies (5)
- Pests and diseases (7)
 - Blight, Phytophthora
 - Gall wasp, Weevil
 - Spoilage mold(s)



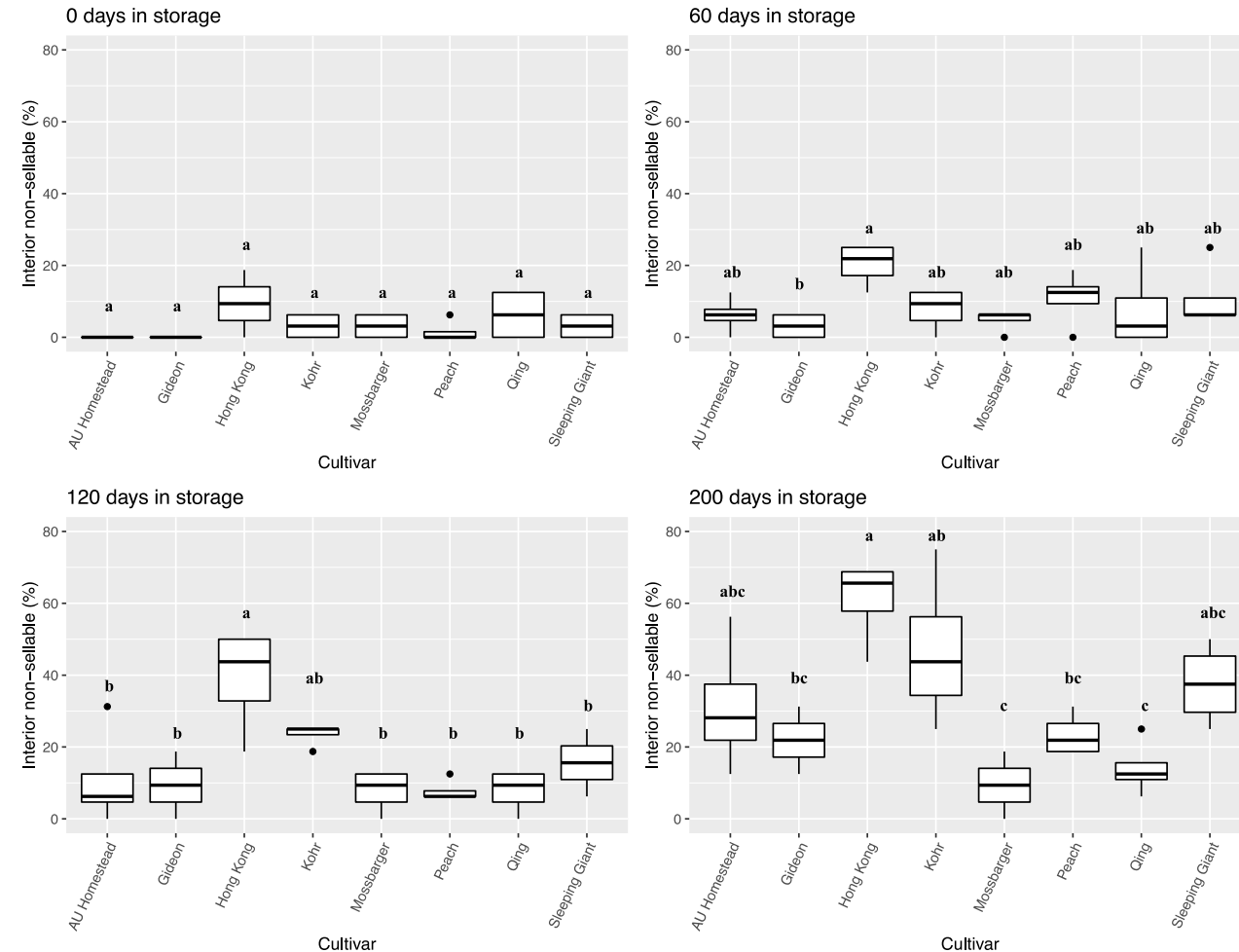
Speaking of spoilage molds

- Four replication of 16 nuts per time point
- Exterior mold (on shell) incidence predominantly arises after 60-days
- Exterior mold resistance suggested in 'Mossbarger' and 'Qing'



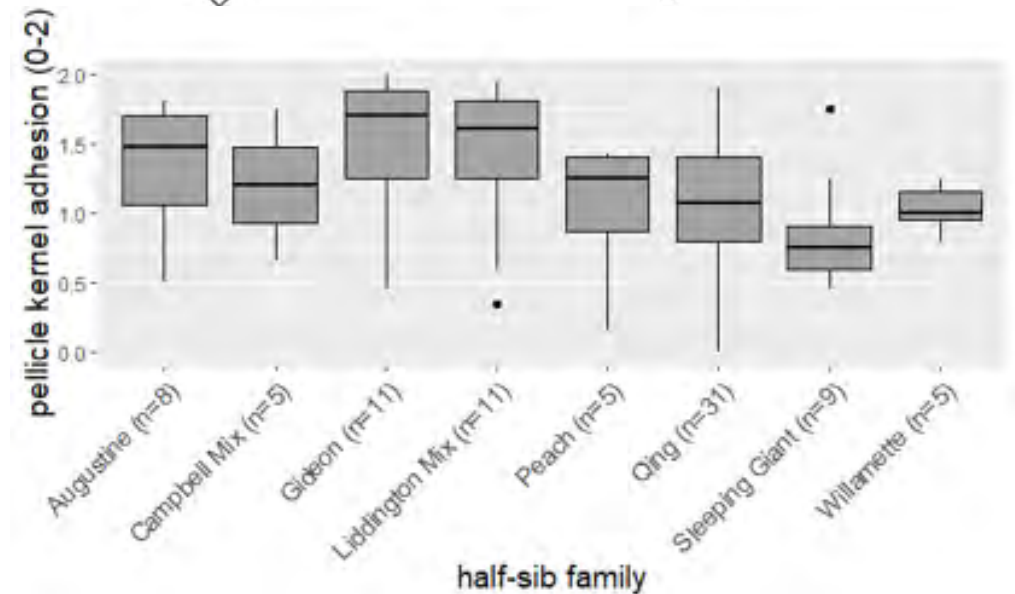
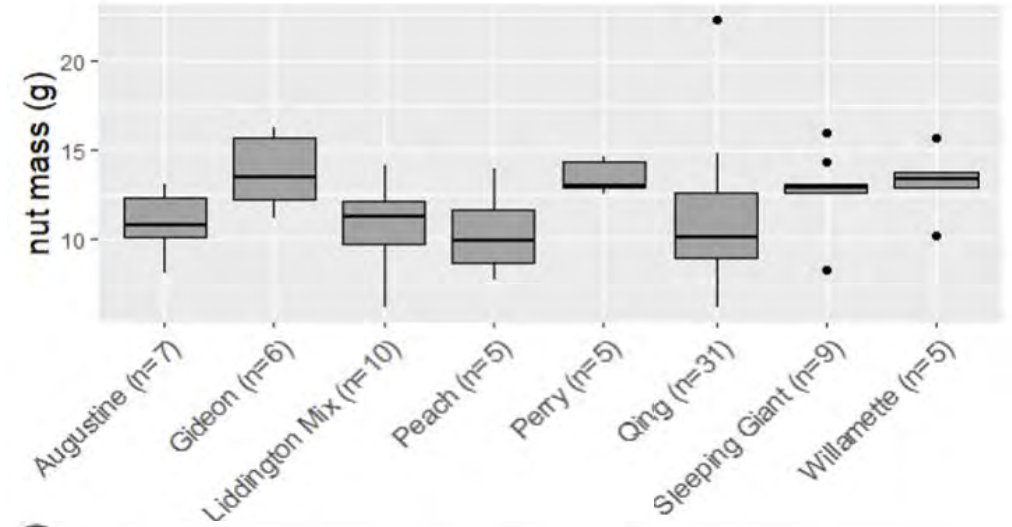
Speaking of spoilage molds

- Similar results with interior mold incidence (i.e., pellicle and kernel)
 - ‘Hong Kong’ incidence much higher
- Interior mold incidence predominantly arises after 60-days
- Interior mold resistance suggested in ‘Mossbarger’ and ‘Qing’
 - Although greater levels of mold than on the exterior



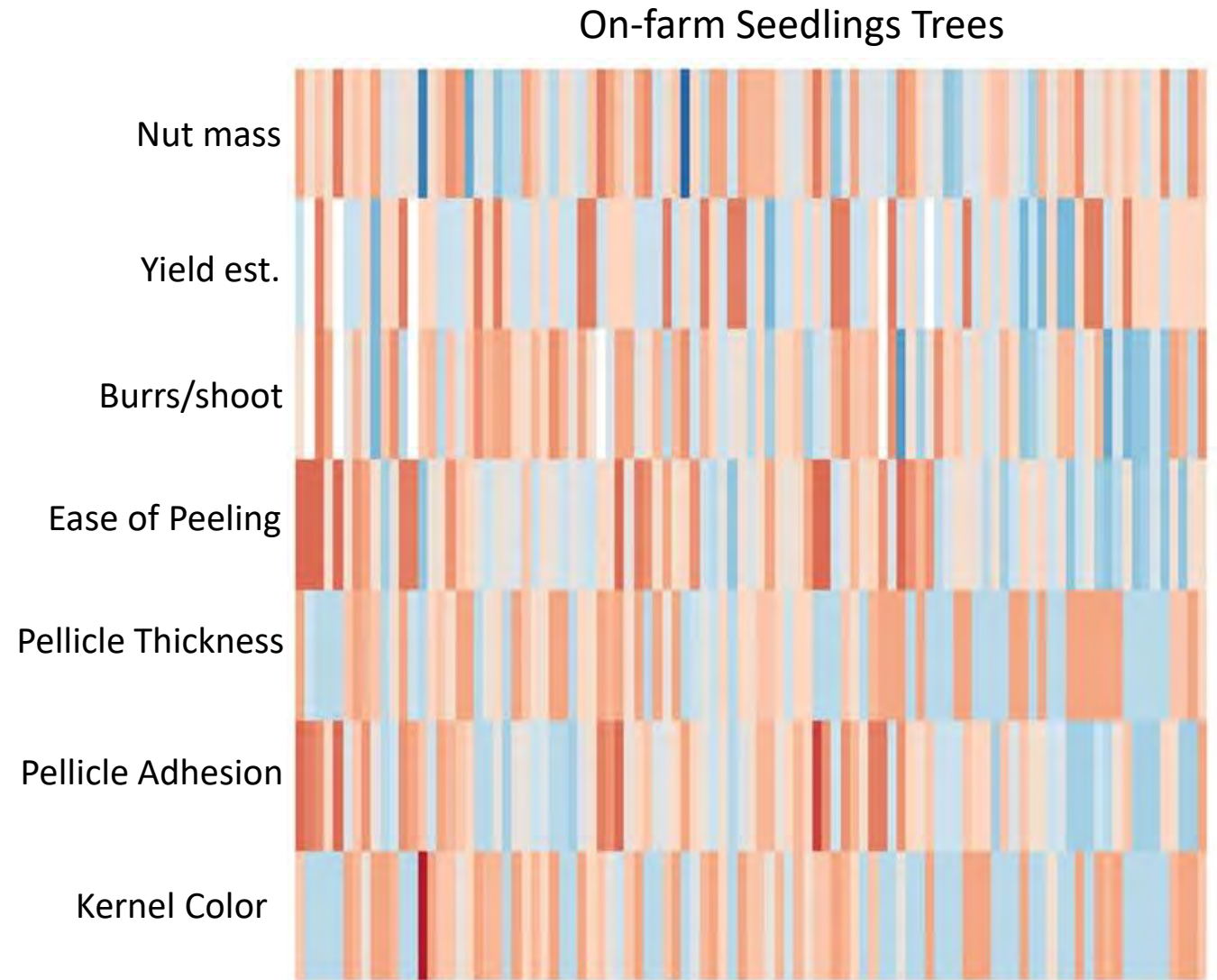
Preliminary Data Snapshot

- *Considerable variation observed across all traits*
- Trait variation explained – sometime by maternal family, other times the individual



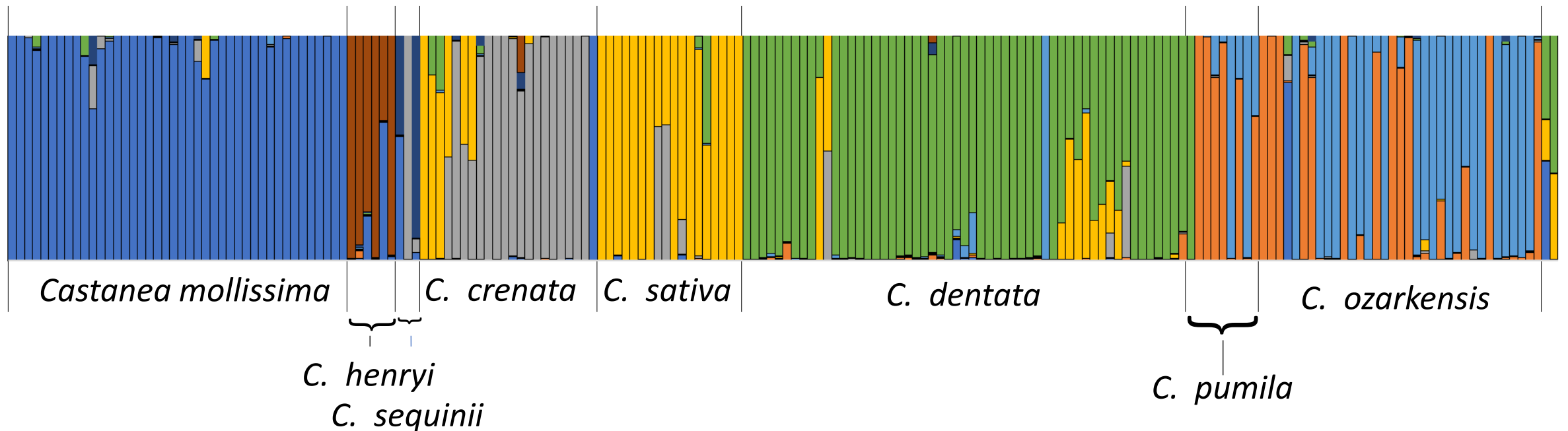
Preliminary Data, Phenotype Subset

- Complimentary next-gen parents revealing themselves (heat map)
- Next – multivariate analysis – a full-view of how genetic diversity is partitioned (PCA, DPCA)



Genotyping

- Use 45 EST-SSRs developed by the Romero-Severson Lab to discern on-farm selections' ancestry & parentage
- Utilize this data in tandem with phenotypic and geography information to assemble “consensus core collections”



Participatory Breeding – Looking Forward

Breeding Goals by Class

1. Stable production by environment
 - Major effect traits is frost avoidance, like late leafing 'Qing'
 - Local adaptations, likely many genes contributing minor effects
2. Durable resistance
 - BER, Phytophthora spp., leaf pests, gall wasps, storage molds
3. High Kernel Quality, low defects
4. High yield
 - Male sterility, canopy architecture, burrs/shoot

*Emphasis is placed on both the performance of the individual as well as its offspring

Controlled Pollinations



Scale of Controlled Cross

- Aim to generate around 10,000 full-sibling offspring in 2021
 - 4,000 pollination bag, dedicated crew
 - Near-term emphasis is to utilize genetic resources
 - i. a large systematic partial diallel
 - ii. Mapping population development
- Long-term emphasis is to incorporate on-farm selections to develop region-minded progeny

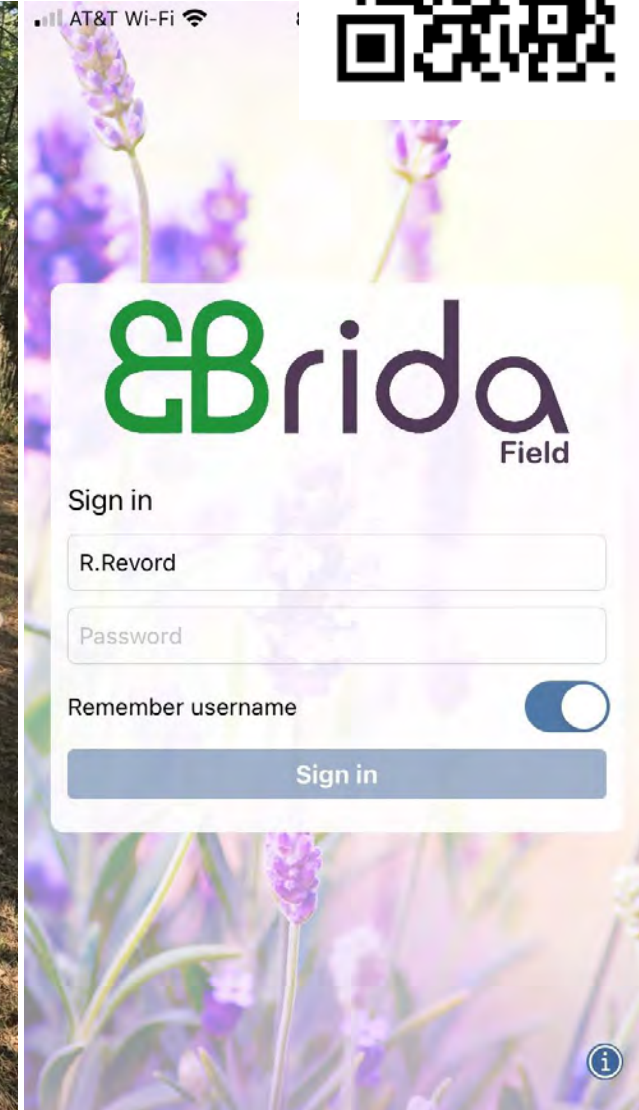


2021 Cross Design *Concept

	Yixian Large Nut	Yixian Great Flavor	Szego	Sleeping Giant	Qing	Perry	Peach	Payne	Mossbarger	Marigoule	Luvall's Monster	Kohr	Jenny	Hong Kong	Gideon	Bouche de Betizac	Auburn Super	Auburn Homestead	Amy
Amy	x																		
Auburn Homestead	x	x																	
Auburn Super		x	x																
Bouche de Betizac			x	x															
Gideon				x	x														
Hong Kong						x	x												
Jenny							x	x											
Kohr								x	x										
Luvall's Monster								x	x	x		x							
Marigoule										x									
Mossbarger										x		x	x						
Payne												x	x						
Peach													x	x					
Perry														x					
Qing														x	x	x			
Sleeping Giant															x	x			
Szego																x	x		
Yixian Large Nut																x	x	x	x
Yixian Great Flavor																x	x	x	x

E-Brida

- Germplasm management database
 - In situ conservation
 - Facilitate on-farm progeny evaluation
- Cloud-based data archiving
- Ease data collection accuracy, maintenance, and sharing



E-Brida

AT&T Wi-Fi 8:23 AM 100%

HARC Spring Phenology 2021 Julian date 4/12/21 | Chestnut, 2021 HARC Repository Tree Done

0037 (R01T04)
R01T04,Gideon

Plots Properties

Find plot Find

- 0043 * R01T01,Jersey Gem R01T01
- 0041 * R01T02,Jenny R01T02
- 0015 * R01T03,Benton Harbor R01T03
- 0037 R01T04,Gideon R01T04**
- 0023 * R02T01,Dallas City Street R02T01
- 0045 R02T02,Kohr R02T02
- 0048 * R02T03,Luvall's Monster R02T03

Group Code Location PI Ancestry

R01T04 New Franklin, Missouri Gideon Gideon

AT&T LTE 10:27 AM 81%

HARC Spring Phenology 2021

Cancel Properties Done

Plots Subplots

Select the properties you would like to view. Please make sure at least one property is visible.

Show all Hide all

- Greentip Visible
- First Leaves Unfold
- Shoot Growth Begins
- Male Catkins Visible
- Glomerules Visible
- Female Flowers Visible
- Stigma visible
- First Male Flowers Open
- 10 -20% of Male Flowers open
- Full Male Flowering

HARC Spring Phenology 2021 Done

0068 (CT2)
CT2,Peach

Greentip Visible 4/14/21

First Leaves Unfold 4/20/21

Shoot Growth Begins 4/26/21

Male Catkins Visible 5/2/21

Glomerules Visible 5/8/21

Female Flowers Visible 5/29/21

1/3

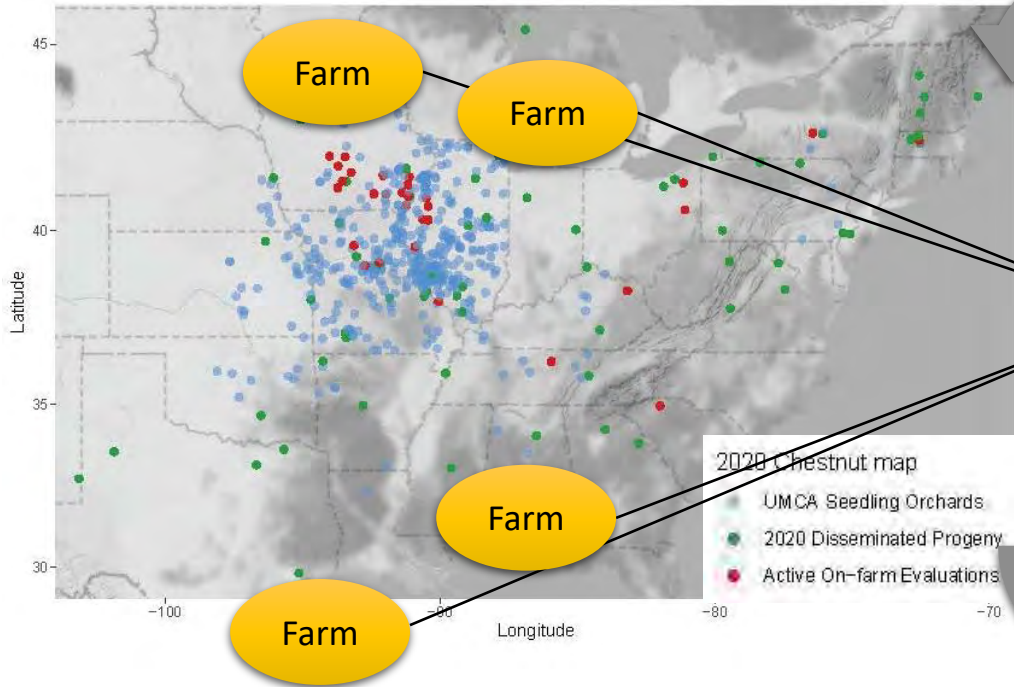
HARC Spring Phenology 2021

0029 (R10T09)
R10T09,Eaton River

Search plots Find

Plots	Greentip Visible	First Leaves Unfold	Shoot Growth Begins	Male Catkins Visible	Glomerules Visible
0017 CT1,Byron CT1	4/14/21	4/20/21	4/26/21	5/2/21	5/9/21
0068 CT2,Peach CT2	4/14/21	4/20/21	4/26/21	5/2/21	5/8/21
0043	4/9/21	4/24/21	4/27/21	5/2/21	

DECENTRALIZED GROWER NETWORK



- ← Full-sib progenies & diversity panels
- ← Scientific methodology guidance
- ← Genotyping, genomic prediction
- ← Germplasm management database
- ← Trait screening & genotypic selection
- ← Communication hub for growers

Chestnut Improvement Network

- Expansive program footprint →
- Field observations/evaluations →
- Phenotypic selections →
- New selections' seed, scions, pollen →
- In situ* conservation →
- Local/regional seed orchards →

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CENTER FOR AGROFORESTRY

RESOURCES:

- Diverse environments
- Large land area, tree care
- Selection criteria insights
- Program support labor
- Income from chestnut sales

RESOURCES:

- Website & database hosting
- Genetic & molecular expertise
- Dedicated research personnel
- Laboratory & data analysis facilities
- Information dissemination

Thank you!

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