Department of Plant and Agroecosystem Sciences
COLLEGE OF AGRICULTURAL & LIFE SCIENCES
UNIVERSITY OF WISCONSIN–MADISON

Nature & Nurture Seeds

KC Tomato

Lessons from Tomato Selection and Breeding

Presenting:

- **Ámbar Carvallo López** – UW-Madison
- **Keith Mueller** – KC Tomato
- **Erica Kempter** – Nature & Nurture Seeds
- **Marissa Nix** – UW-Madison

Organic Seed Growers Conference 2025
Corvallis, OR - February 28, 2025

Participatory Tomato Breeding in the Midwest

Project 1: Tomato selection for organic systems in the Midwest

- Traditional breeding and selection in collaboration with farmers, chefs, and researchers

Project 2: Collaborative plant breeding network development for organic systems in the Upper Midwest

- KC Tomato
- Nature & Nurture Seeds

Outline:

- Methods on PPB
- Challenges
- Future opportunities
- New tomato varieties highlights

1. Tomato selection for organic systems in the Midwest

- Definition of breeding objectives
  - Based on previous research (Hoagland et al., 2015, UW-Madison reports) AND
  - Farmer's feedback from various conference roundtables (Marbleseed conference, *previously MOSES*)

- Traits prioritized
  - Yield
  - Disease resistance: Septoria leaf spot, early blight, leaf mold, powdery mildew
  - Fruit quality

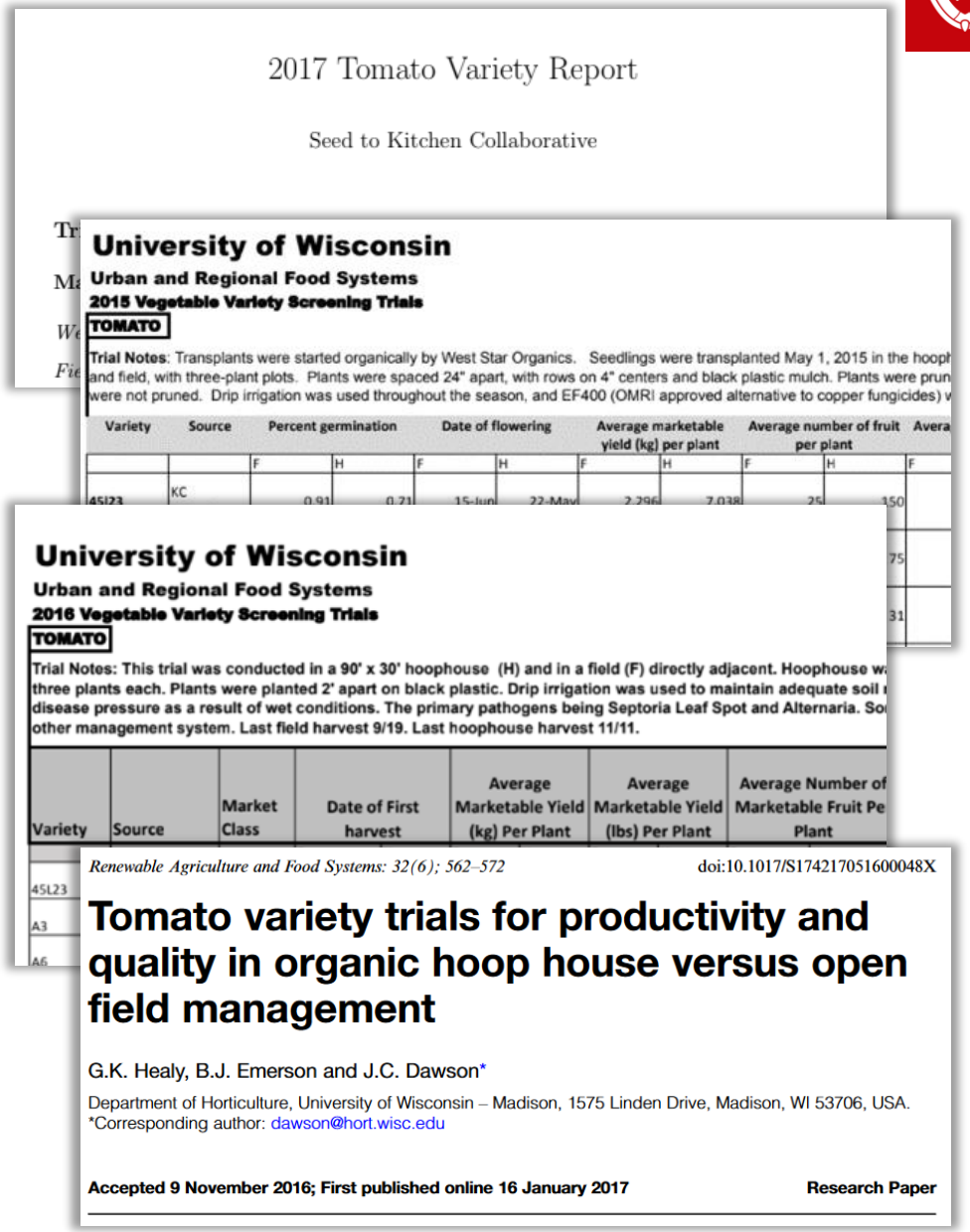
Definition of traits of interest

Hoagland et al. (2015)

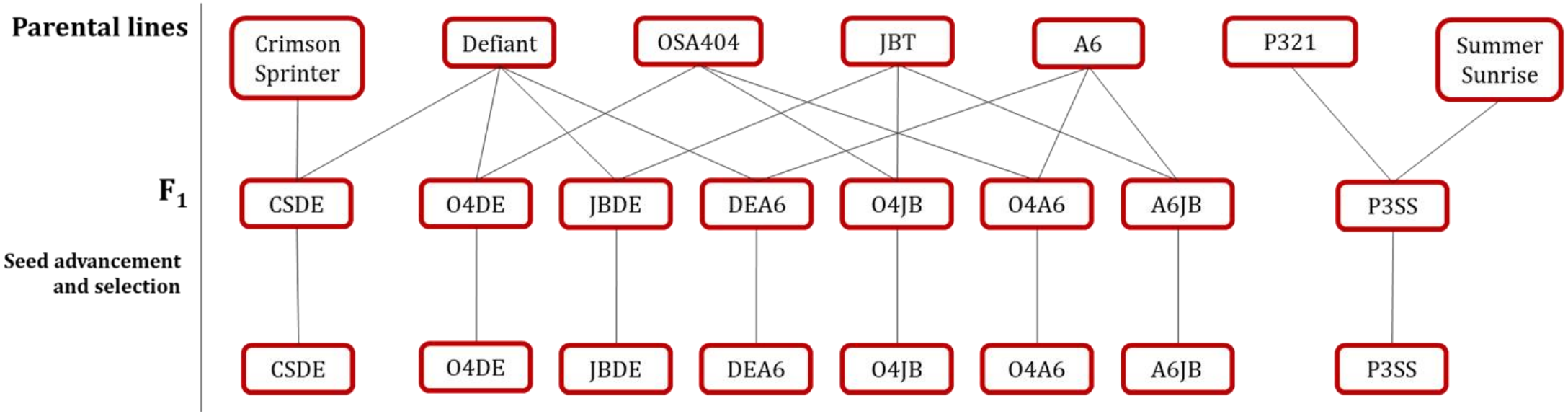
Table 3. Percentage of Midwest conventional (CO) and uncertified organic and certified (OR) vegetable growers indicated that a specific trait was one of their three most desired traits for inclusion in a tomato breeding program.

	Number of responses		Percent of respondents who identified the trait among their top three			
Trait	OR	CO	OR	CO	Difference	SE
Flavor	122	98	79.2	72.6	0.066	0.05
Disease resistance	96	112	62.3	83	–0.206*	0.051
Crack resistance	59	76	38.3	56.3	–0.18*	0.058
Nutritional quality	42	6	27.3	4.4	0.228*	0.04
Color, shape	28	38	18.2	28.1	–0.1*	0.05
Weed competitiveness	14	14	9.1	10.4	–0.013	0.035
More plants per fruit	14	13	9.1	9.6	–0.005	0.034
Maturity	12	6	7.8	4.4	0.033	0.028
Storability	8	11	5.2	8.1	–0.03	0.03
Stronger roots	9	5	5.8	3.7	0.021	0.025
Water use efficiency	9	4	5.8	3	0.029	0.024
Compact plants	5	8	3.2	5.9	–0.027	0.025
Nutrient use efficiency	4	1	2.6	0.7	0.019	0.015

*Values reflect differences between grower groups (≥ ± 0.01).



Crossing scheme



On-station evaluation

Moved to high tunnel evaluation only.

Traits evaluated

- Yield (marketable weight, fruit count, average fruit weight).
- Diseases: septoria leaf spot, early blight, powdery mildew, leaf mold.
- Fruit quality: Brix, CA
- Fruit flavor: tastings (sweetness, acidity, umami, intensity, overall).

Farmer participation in selection

- 6 organic farmers in 2020
- 5 organic farmers in 2021
- More farmers in 2022, 2023, and 2024 (SeedLinked)

On-farm evaluation, Luna Circle
Madison, WI, 2021

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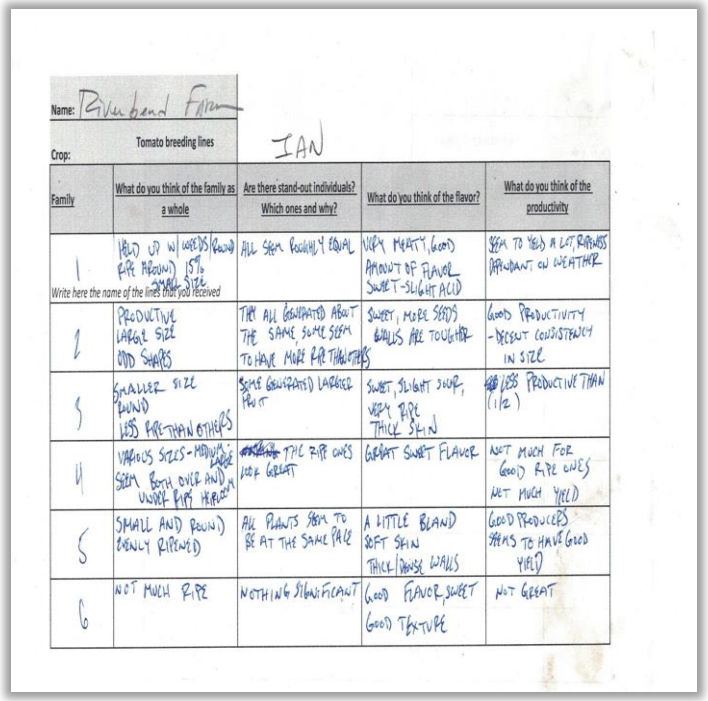
Voss Organics Summer 2020 evaluation					
Family	**OSA 404 x Defiant**	**A6 x JBT**	**OSA404 x JBT**	**OSA404 x A6**	**JBT x Defiant**
What do you think of the family as a whole	Liked the plant size	Liked A6 family best for color, flavor, productivity, and size. clear winner	Most blossom end rot. Not preferred	Liked A6 family best for color, flavor and size	Liked the plant size
Are there stand-out individuals? Which ones and why?		Best: striking color and shape		Best: manageble plant habit, great flavor, large size, striking color	
What do you think of the flavor?	good	Best	good	Best	good
What do you think of the productivity	strong	productive in number and size	tendency toward end rot reduced marketable fruit	strong	Good


Name: Riverbend Farm
Crop: Tomato breeding lines
IAN

Family	What do you think of the family as a whole	Are there stand-out individuals? Which ones and why?	What do you think of the flavor?	What do you think of the productivity
1 Write here the name of the lines that you received	HELD UP W/ WEEDS/ROUND RIPE BROWN) 15% SMALL SIZE	ALL SEEM ROUGHLY EQUAL	VERY MEATY, GOOD AMOUNT OF FLAVOR SWEET-SLIGHT ACID	SEEM TO YIELD A LOT, RIPENESS DEPENDANT ON WEATHER
2	PRODUCTIVE LARGE SIZE ODD SHAPES	THEY ALL SEGREGATED ABOUT THE SAME, SOME SEEM TO HAVE MORE RIP THAN OTHERS	SWEET, MORE SEEDS WALLS ARE TOUGHER	GOOD PRODUCTIVITY - DECENT CONSISTENCY IN SIZE
3	SMALLER SIZE ROUND LESS RIP THAN OTHERS	SOME SEGREGATED LARGER FRUIT	SWEET, SLIGHT SOUR, VERY RIPE THICK SKIN	LESS PRODUCTIVE THAN (1/2)
4	VARIOUS SIZES - MEDIUM, LARGE SEEM BOTH OVER AND UNDER RIPE HERE	~~ONE~~ THE RIPE ONES LOOK GREAT	GREAT SWEET FLAVOR	NOT MUCH FOR GOOD RIPE ONES NOT MUCH YIELD
5	SMALL AND ROUND EVENLY RIPENED	ALL PLANTS SEEM TO BE AT THE SAME PACE	A LITTLE BLAND SOFT SKIN THICK/INSIDE WALLS	GOOD PRODUCERS SEEMS TO HAVE GOOD YIELD
6	NOT MUCH RIPE	NOTHING SIGNIFICANT	GOOD FLAVOR, SWEET GOOD TEXTURE	NOT GREAT

On-farm vs. On-station selection

- On-station:
  - Yield, disease resistance, fruit quality (tastings)
  - Medium-sized slicer
  - Reds and dark pinks
  - Uniformity
- On-farm:
  - Different market classes, novel phenotypes (medium-sized with green stripes, for example)
  - Uniformity

OSA404 x Japanese Black Trifele

Flavor evaluation: Chefs collaboration

- Evaluation of the organoleptic characteristics.
- Understanding of the different uses each variety could have.
- Tastings carried out at a local restaurant.

Published results

HortScience 59(9):1299–1307. 2024. https://doi.org/10.21273/HORTSCI17799-24

Improved Tomato Breeding Lines Adapted to Organic Farming Systems Have Enhanced Flavor, Yield, and Disease Resistance

Ambar Carvallo Lopez, Marissa Nix, Thomas Hickey, and Julie C. Dawson
Department of Plant and Agroecosystem Sciences, University of Wisconsin–

Table 3. Summary of on-farm evaluations of tomato breeding lines grown by organic farmers in the Upper Midwest United States in 2020 and 2021.

Family	General	Flavor	Productivity	Fruit characteristics	Other comments
'Crimson' × 'Defiant' (CSDE)	Competitive with weeds, healthy	Good acid/sweet balance, tough skin; best of all	High–moderate	Medium size	Late
OSA404 × 'Japanese Black Trifele' (O4JB)	Good size; great disease resistance to EB	Good, sweet flavor Heirloom appearance	High–good	Some medium, some larger sized	Short harvest; best overall; yields higher at the beginning of the season
JBT × 'Defiant' (JBDE)	Healthy plants	Very tasty, sweet flavor; tough skin	Moderate; very productive for one farm	Medium size	No data
A6 × JBT (A6JB)	Typical heirloom; not good disease resistance; prone to rot	Sweet, good flavor	Low	Big, heirloom type	High variability in fruits, some purples; soft fruit
OSA404 × A6 (O4A6)	Decent leaf disease resistance	Very sweet	Variable	Medium sized	Took a long time to ripen; soft fruit; radial cracking and green shoulders

Top rated, on-farm + on-station

CSDE

- Indeterminate
- Medium-sized red slicer
- 13.93 lb/plant
- ºBrix: 5.65
- CA (%): 0.45
- Good sweetness/acidity balance.

JBDE

- Indeterminate
- Medium-sized dark red slicer
- 11.4 lb/plant
- ºBrix: 5.01
- CA (%): 0.42
- Good umami flavor, thick skin.

Top rated, on-station + industry

A6JB

- Indeterminate
- Large heirloom type, dark red with some green shouldering
- 10.0 lb/plant
- ºBrix: 4.91
- CA (%): 0.39
- Sweet, good balance.

O4DE

- Indeterminate
- Large heirloom type, light red with some green shoulders
- 16.9 lb/plant
- ºBrix: 3.91
- CA (%): 0.25
- Balanced flavor

Challenges encountered

- Disease pressure variability.
- Differences in farmer selection criteria vs. on-station priorities.
- Difficulty maintaining farmer engagement over seasons - especially during and after COVID pandemic.

Take-home tastings

Broader impact & Next steps

- Top varieties:
  - Commercial release
  - Use as parental lines for other breeding programs

- Reference workframe to replicate in different environments, markets, traits of interest, crops, etc.

2. Collaborative plant breeding network development for organic systems in the Upper Midwest

- Overview
- Keith Mueller of KC Tomato
- Erica Kempter of Nature & Nurture Seeds
- Benefits & Challenges of the Collaborative Project

Overview

SKC
Seed to Kitchen Collaborative

2014: beginnings with variety trials for 11 fruit & vegetable crops

- 2019: submitted OREI grant
  - create new varieties adapted for organic systems
  - build network from plant breeder to consumer
  - contribute to development of SeedLinked
- 2020: awarded grant
- 2021-2024: participatory trials

KC Tomato

Keith Mueller - tomato breeder and farmer, collaborator of the project.

Keith’s Video Recording

Tomato Breeding Program

Nature & Nurture Seeds

2. Collaborative plant breeding network development

Breeding Objectives

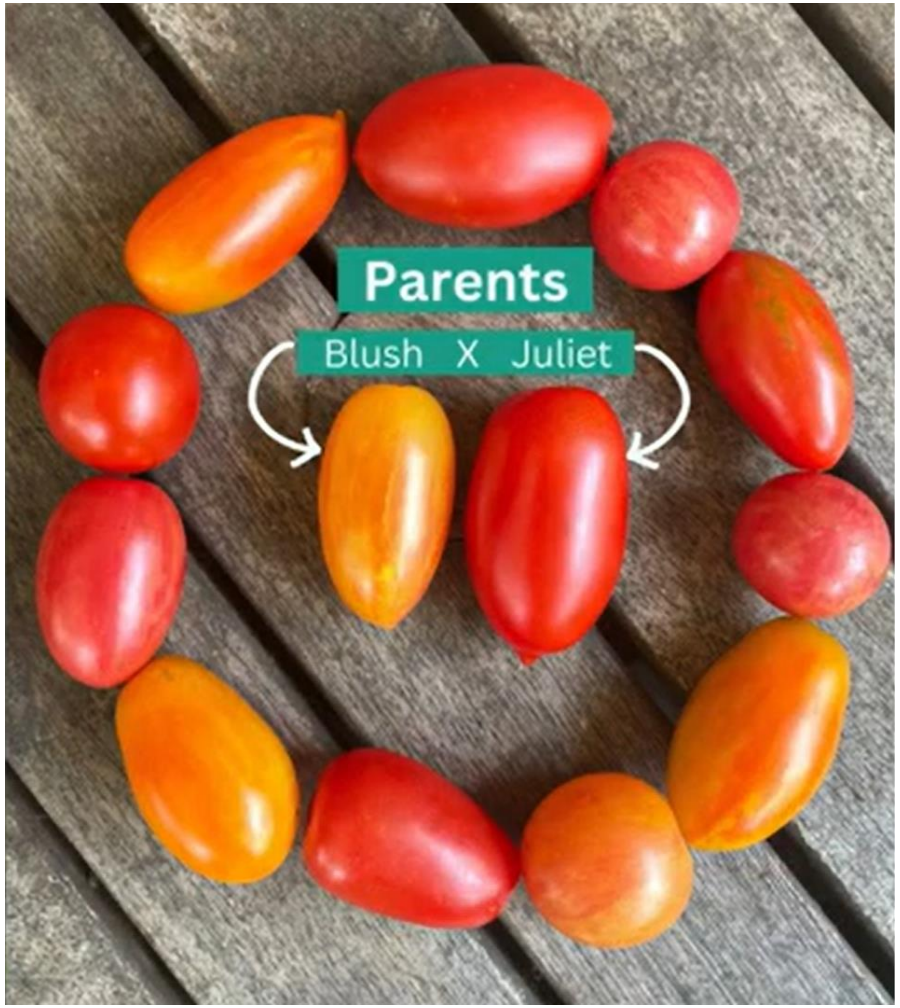
- General breeding objectives
  - Cherry, cocktail, & saladette
  - Novel phenotypes
    - Striped
    - Color combos that are not currently available
  - Good flavor
  - High vigor
  - Disease resistance - diseases that matter in the upper midwest
  - Seeds that farmers can save (OP)
  - Adapted to:
    - organic farming systems
    - Field conditions

Breeding Process: The Cross

2018

Juliet

- Saladette size & shape
- Color (red flesh, yellow skin)
- Good flavor
- Disease resistance



Blush

- Saladette size & shape
- Excellent flavor
- Vigorous & high yielding OP
- Stripes (green stripe trait)
- Yellow flesh & clear skin (to create a lot of color combinations)

Breeding Process:

F2 (2020)

- Grew 72 plants
- Selection
  - Removed (didn't save seeds from) plants with low vigor and bad flavor
  - Did mass selection based on phenotype:
    - Red saladette showing gold stripes (homo or heterozygous for green stripe trait)
    - Red saladette without stripes
    - Yellow fruited saladettes
    - Yellow fruited cherries

- Why did I do mass selection?
  - Optimize maintaining genetic diversity in my selections
  - Reduce the number of plant families that I would need to grow later
  - Disadvantage: you are relying a bit more on random chance

Collaborative Process

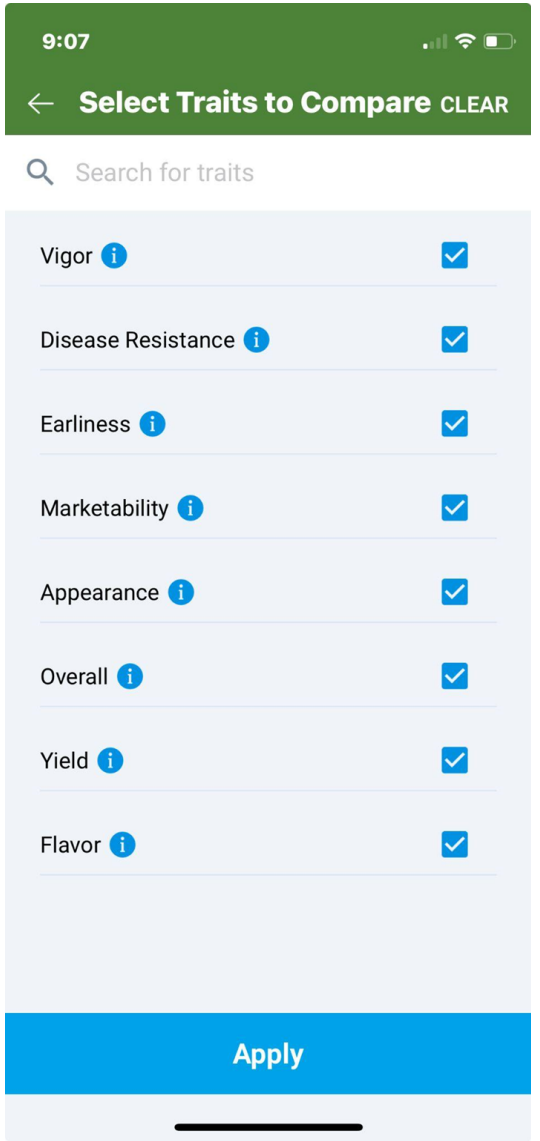
Fall 2020: I sent the bulked seed to Julie Dawson to use as the early lines for the collaborative project.

2021 summer (F3):

- Seeds of the bulked seed were sent out to farmers & gardeners to grow and select their favorites. (also at N&N Seeds and UW farm station)
- These saved seeds were sent back to UW and they became the plant families that we worked with

2022-2024

- Winters: Planted and advanced in UW greenhouses
- Summers:
  - seeds sent out to farmers, gardeners, & grown at N&N Farm & UW Station
  - Plants evaluated using Seedlinked App
  - Selections made for the best plants



Traits Evaluated using Seedlinked App

Our First Introduction:

New variety coming: Jewell

- Pink cherry with golden stripes
- Very early
- Excellent flavor

Benefits & Challenges of the Collaborative Project

- Creation of network across the upper Midwest
- Decentralization of trials
- Creation of region-specific varieties
- Instant results with SeedLinked
- Increased diversity in varieties
- Data for new releases

Conclusions

- Applicable to other crops and regions
- Framework for future projects
- Created abundant new material

Acknowledgments

- Dawson Lab team
- Collaborating Chefs and Growers
- West Madison Ag Station, UW-Madison
- Organic Collaborative UW-Madison
- TOMI, NOVIC, and WISCORE projects

WARF
Wisconsin Alumni Research Foundation

AAM4295
Final evaluation of advanced tomato breeding lines of variety release

UW Organic Collaborative
UNIVERSITY OF WISCONSIN–MADISON

Collaborative plant breeding for organic tomatoes in the Upper Midwest

SARE

NC-SARE-LN17-388
Improving farmer options for sustainable and profitable direct-market tomato production and high tunnel management in the Upper Midwest

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

2019-51300-30245
TOMI II: Tomato organic management and improvement

2020-51300-32176
Collaborative plant breeding network development for organic systems in the Upper Midwest

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