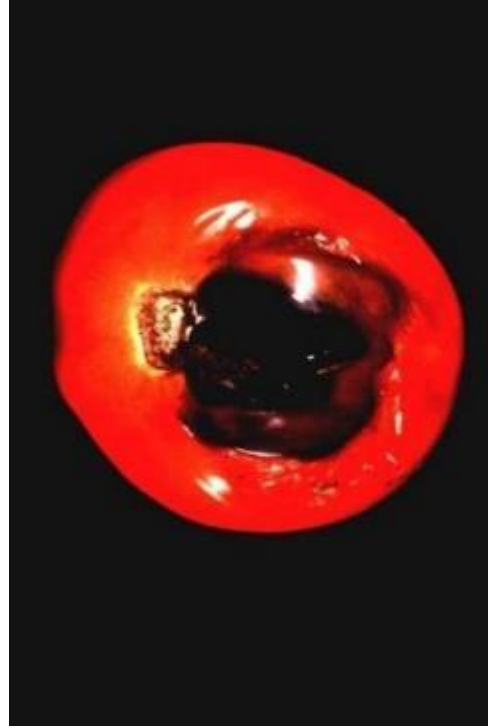


Current and Upcoming Tomato Cultivars with Improved Resistance to Fungal and Bacterial Diseases

Michael Glos, Taylor Anderson, and Martha A. Mutschler
Plant Breeding and Genetics Section, SIPS Cornell University

Margaret McGrath, Plant Pathology, Cornell University



Photos: Tom Zitter

Late Blight

Phytophthora infestans

Early Blight

Alternaria spp.

Septoria Leaf Spot

Septoria lycopersici

Late blight (an oomycete disease) and early blight & *Septoria* leaf spot (fungal diseases) are controlled now by applying fungicides repeatedly

All three diseases must be controlled to protect tomato yield & fruit quality while reducing use of fungicides and copper sprays

Strategy for Combining Resistances Within a Quality Tomato Line.

Breeding strategy was to combine resistance genes for each of the diseases to create lines resistant to all three diseases.

This was accomplished by creating a series of lines that possessed:

- The Ph2 and Ph3 genes that give excellent control of late blight
- Either both SLS-1 and SLS-2 or only SLS-2 for resistance to Septoria Leaf Spot
 - Best control if plants are separated by *ca.* 15 feet from susceptible tomatoes
- Strong Early blight tolerance that strongly protects stems/peduncles, provides less control on foliage
 - Number / location of early blight genes not known at the time

In field trials, the resulting lines reduced need for fungicides by up to 75%, even when field was heavily inoculated and conditions favored the diseases.

Current Hybrids with Multiple Fungal Disease Resistances

Standard Slicers

Iron Lady

- (High Mowing Organic seed)
- V/FF/LB/SLS/EB
- Moderate size (150gm) oblate



Iron Lady

Stellar

- (Pan American Seeds)
- V/FF/LB/ SLS/EB
- Moderate size (150gm), deep round



Stellar

Current Hybrids with Multiple Fungal Disease Resistances

BrandyWise: Half Heirloom Slicer

- Fruition Seed Company) **New 2018**
- V/FF/LB/SLS/EB; organic
- Flavor succulence similar to Brandywine
- Large attractive red fruit that does not have cracking/large catface of Brandywine



Summer sweetheart: Compari tomato

- Fruition Seed Company **New 2018**
- V/FF/LB/SLS/EB; organic
- Sweet, excellent overall flavor, little cracking



Multiple Disease Resistant Plum: New in 2019

Plum Perfect (High Mowing Organic Seeds):

- Verticillium/Fusarium 1, 2, 3/Mi (nematode)/Pto (speck)/Sw-5 (TSWV)/LB (Ph3), also jointless, uniform ripening
- Extremely productive, with large firm fruit; very good flavor & color;
- Excellent fresh chopped (holds shape when diced) or when cooked / canned



Conclusions on Current Hybrids

Several of the larger seed companies are currently using the Cornell lines for transfer of the combined resistances into additional lines, and future hybrids.

A number of hybrids with combined early blight/late blight resistance are also available (mostly derived from NCSU program)

- For example, Mountain Merit and Mountain Magic

ANY QUESTIONS ABOUT CURRENT HYBRIDS WITH COMBINED RESISTANCES?

Bacterial Spot and Bacterial Speck Control

- Bacterial disease control is recognized as a high priority area for tomatoes grown in the Northeast
- Copper sprays are currently the controls of bacterial diseases
- Resistances to bacterial diseases needed to reduce use of copper sprays,
- Other university tomato breeders and plant pathologists had identified resistances to these diseases, mapped and created markers for them
- The Cornell program is transferring the bacterial resistance genes into the best of the combined fungal/Oomycete resistance tomato lines.

Bacterial Spot



- Disease is caused by complex of four Xanthamonads
 - X. euvesicatoria*
 - X. vesicatoria*
 - X. perforans*
 - X. gardneri*
- *Xanthomonas gardneri* was isolated in the Northeast
- Several sources of resistance are available
 - *Rx-3*: on Chr 5: controls race T1 (*X. euvesicatoria*)
 - *Rx-4*: on Chr 11: controls race T3 (*X. perforans*)
 - *QTL-11*: on Chr 11: Partially controls disease all races
- Transferring all three of these resistances into NY adapted tomatoes that already have combined fungal resistances
- Existence of markers, and use of “forward and backward” marker selection, allowed transfer in only 6 generations (2.5 years) including all steps.

Bacterial Speck



- The resistance gene *Pto* controls the predominant race (Race 0) of *Pseudomonas syringae* pv. tomato
- *Pto* is being transferred into NY adapted tomatoes that already have combined fungal/Oomycete resistances
- Our source for both *Pto* and *Rx3* (bacterial spot) is the same, and both are on chromosome 5, so they were transferred simultaneously
- Existence of markers for these resistance genes, and use of “forward and backward” marker selection, allowed transfer in only 6 generations (2.5 years) including all steps.



Completing Transfer of Bacterial Spot Resistance (QTL11/Rx4) to Combined Fungal Resistant Lines

- Plants recovered fresh market appearance in greenhouse
- 2018 Field Trials in 3 Locations (Freeville, Long Island, Ohio) confirmed plant and fruit type, and supported selection for quality parameters.
- Verified QTL-11 and Rx4/Xv3 control of disease.
- Lines are ready to use in creation of experimental hybrids

Completing the Transfer of Bacterial Speck & Spot Resistances (*Pto* & *Rx3*) to Combined Fungal Resistance Lines

- We identified the best *Pto*/*Rx3* lines in the field this summer based on phenotypic performance
- Will perform replicated field trials of new lines in 2019
- Crossing the QTL11/*Rx4* and *Pto*/*Rx3* lines to produce hybrids, then lines.



Existing Control of Early Blight

Resistant

Susceptible



Enhanced Control of Early Blight

- Ohio line used for bacterial resistance project was found also to have early blight tolerance protecting only foliage
- Genetics of the early blight control in the Cornell vs. the Ohio lines showed that
 - The Cornell combined fungal resistant tomato lines have two QTL for control of early blight.
 - The Ohio line possesses an additional QTL for control of early blight.
 - This work also selecting markers flanking the three QTL, allowing for marker based selection
- Inoculated trials compared early blight diseases in plants with 0, 1, 2, or all three early blight QTL



Impact of EB QTL

Plants lacking all of the EB resistance QTL are profoundly susceptible in stems and foliage



Lines with only the Chr. 5 QTL from the OHIO parent have modest control of foliar disease



Impact of EB QTL

Lines with the CH1 and CH9 QTL of the Cornell line have strong control of stem disease and moderate control of foliar disease



Lines with all of the EB QTL show strong control of stem disease and improved control of foliar disease



Progress on Enhanced EB-Resistant Lines

- Selections are being made in the greenhouse this winter to complete the transfer of the additional EB QTL into the best current Cornell Combined fungal resistance line.
- This additional EB QTL combined with the two EB QTL already in the Cornell LB/EB/SLS lines should increase the level of EB control in the resulting lines
- The new lines will otherwise be like the Cornell lines already used in hybrid
- The lines will be completed Spring 2019, then the lines and experimental hybrids would be field trialed as soon as possible thereafter.

In Summary:

- Our tomatoes are adapted to the Northeast climate and produce high-quality fruit while combining resistances to several major diseases of tomato.
- Our recent projects are important steps towards protecting grower income, reducing production costs, and limiting negative environmental externalities from chemical sprays.
- Look forward to several new lines and hybrid varieties becoming available in the next several years.



Acknowledgements

Mutschler Breeding Program (Cornell)

- Martha Mutschler
- Taylor Anderson
- Darlene De Jong
- Stella Zitter
- Michael Glos
- Julie Bojanowski



Cornell Cooperators

- Chris Smart
- Mike Gore
- Meg McGrath
- Teresa Resnick



Francis Breeding Program (OSU)

- David Francis
- Eduardo Bernal

