

Final Report FNE03-452: Selecting Heirloom Tomato Varieties for Disease Resistance

Jeremy Barker Plotkin
22 Poole Rd.
Belchertown, MA 01007
(413) 323-9608; jbp@the-spa.com

Goals of Project:

I would like to breed resistance to *Alternaria* blight and *Septoria* leaf spot into some of the heirloom tomato varieties which I grow. I have a very good market for heirloom tomatoes, but disease pressure cuts my season very short. My plants are typically very productive in mid- to late-August, with declining productivity through the month of September. My market for tomatoes actually increases in September, and we often don't have frost until early October, so if I could reduce disease losses, I could greatly increase my yields and profitability. I typically put in a late planting for September, but we often have wet conditions in September and disease pressure is high even in the late plantings. I have observed variation between varieties in disease susceptibility, and would like to do some more targeted work to select and breed for disease resistance. My marketing strategy for heirlooms relies on having a full palette of colors, so the ideal scenario would be several resistant varieties in different colors.

My breeding strategy is working to develop what is known as horizontal resistance. This strategy is different from the standard technique, known as vertical resistance, which consists of finding single traits that code for resistance. Instead, a complex of several resistance traits is developed. This is accomplished by growing plants under high disease pressure, and selecting the individual plants that are most resistant. These resistant individuals are crossed, and then grown out again under disease pressure for repeated cycles of re-selection. Vertical resistance is typically short-lived, since a single mutation in the disease can overcome the resistance mechanism; horizontal resistance is a more robust type of resistance.

Farm Information

I rent an eleven-acre (4-5 tillable acres) parcel of land from the New England Small Farm Institute (NESFI) in Belchertown, MA. The land is part of a larger parcel of land that is owned by the Commonwealth of Massachusetts and managed by NESFI. 1999 was my first year of production; I had been working on vegetable farms or studying agronomy (I finished my M.S. in Plant, Soil and Environmental Science from the University of Maine in spring 2000) for seven years prior to that. I cultivated about 4 acres in 2002. The soil is a Woodbridge sandy loam soil which is excellent for vegetable production, particularly after several years of rock-picking and build-up of organic matter. My primary crops are mixed vegetables. I have been certified organic by NOFA/Mass since 2000. I manage a marketing cooperative of the farmers at NESFI; together we operate a farm stand on the site and go to the Amherst, MA and Cambridge, MA Farmer's Markets. In 2002, I increased production of heirloom tomatoes to meet two wholesale markets in addition to the retail markets I already served. The first wholesale market was the local Bread and Circus supermarket, and the second was the

New American Farmer's Initiative, which brought Massachusetts produce to upscale restaurants in New York City. The tomatoes were very well-received by both markets. In 2003 and 2004, I maintained my production of heirlooms at the same level as in 2002. Production was good although a wet season and heavy disease pressure cut the season quite short in 2003.

Cooperators:

John Navasio, the technical director, has helped through phone consultation on plot design, evaluation and selection. Eli Kauffman and C.R. Lawn have coordinated outreach through the Restoring Our Seed (ROS) project. Lawrence Winship has provided winter greenhouse space at Hampshire College for grow-out and crossing of candidate strains. Ruth Hazzard has provided help in plot evaluation and will help to publish results at the end of the project.

Project Activities

2003 methods

In 2003, I established a disease nursery plot which had been used in 2002 for tomato production and which had shown heavy disease pressure in that season. Six varieties of heirloom tomatoes were grown in the plot, along with resistant and susceptible varieties (for comparison), in a randomized block design with three repetitions. The varieties were Green Zebra, Pruden's Purple, Cherokee Purple, Carbon, Indian Moon, and Nebraska Wedding, and Aunt Ruby's German Green for the susceptible check, and JTO-99197 for the resistant check. These varieties are my most productive and reliable varieties representing a wide range of color. Six varieties were used instead of the 7-10 referred to in my proposal due to space constraints. I used two similar purple varieties (Cherokee and Carbon) and two similar yellow varieties (Indian Moon and Nebraska Wedding) to see if one showed better resistance. The plants were evaluated for foliar disease levels on three dates in August and September 2003. Weekly disease ratings were indicated in my proposal, but despite my best intentions, I was unable to afford the time for that many ratings. Ratings from 1 (least disease) to 9 (most disease) were assigned to each plant. For each variety, the block that had the highest average disease ratings was determined. Yield data was not taken due to time constraints, and because differences between varieties was dramatic enough that I felt a relative ranking was as effective as a numerical figure. Seed was saved from the best-performing plants in each of those blocks. This led to selection of 2-3 individuals from each variety. Seed from these individuals was grown out over the winter 2003-4 at the Hampshire College greenhouse. I made crosses by hand-pollination between individuals within each variety. Unfortunately, the tomatoes did not produce seed in time for planting in 2004.

2003 Results and Discussion

Following are the average disease ratings per variety in 2004, listed in descending order of performance.

Variety	Disease Rating	Relative Yield	Relative marketability
Aunt Ruby's German Green ("susceptible check")	4.96	Low	Low
Indian Moon	5.62	High	High
Nebraska Wedding	5.97	High	High
Pruden's Purple	5.98	Medium	Low
Green Zebra	6.15	High	High
Carbon	7.08	Medium	Low
Cherokee Purple	7.08	Medium	Low
JTO-99197 ("resistant check")	8.41	High	Low

Differences in disease levels were more readily apparent between varieties than between plants within a variety, but enough variation was found between plants to select the best individuals. The relative ranking based on foliar disease levels does not tell the whole story. Both *Alternaria* and *Septoria* progress more rapidly after fruiting commences, as the plant puts its energy into fruit production. The more determinate varieties tended to fare the worst in foliar disease levels as they completely stopped producing leaves after fruiting. Indeterminate varieties did especially well because the plants put on a second flush of foliar growth in the later part of the season, after the extremely humid August weather was finished. The two opposite extremes are Aunt Ruby's, which produced immense quantities of lush green foliage and barely any fruit, and JTO-99197, which essentially died, and was loaded with sun-scalded, rotten fruit. Neither variety is useful under heavy disease pressure. The especially poor performance of JTO-99197, which is marketed as resistant to *Alternaria*, led me to believe that *Septoria* was the dominant disease in 2003. In the middle end of the spectrum is where the more interesting results lie. Indian Moon and Nebraska Wedding were both heavy producers of nice fruit, and showed moderately low foliar disease levels. Green Zebra was also a heavy late producer with moderate foliar disease. All three of these plants are indeterminate, and productive of both fruit and foliage. Pruden's Purple, on the other hand, received moderate foliar disease levels, but had very low yields of marketable fruit (total fruit yields weren't low as with Aunt Ruby's, but most of the fruit was rotten). Pruden's showed the earliest onset of *Alternaria*, but the vines seemed to recover especially well and put on a second flush of foliage. Pruden's relatively good performance in spite of early *Alternaria* infection support the idea that *Septoria* was dominant in 2003. Carbon and Cherokee Purple seemed to be more determinate, producing a heavy early fruit set (mostly rotten) on vines which died rapidly.

2004 Methods

For the 2004 season, I decided to focus on Cherokee Purple for more intensive selection. Three strains of Cherokee Purple were grown out: an unselected strain from the same seed packet I planted in 2003, and seed from two of the most disease resistant plants found in 2003. Carbon and Nebraska Wedding were eliminated, since they had

showed no difference with their counterparts. Seed from three 2003 selections of each Green Zebra and Indian Moon was grown out in 2004. On the recommendation of technical director John Navasio, Crimson Sprinter was added as a resistant check, and JTO-99197 was used as a susceptible check. Pruden's Purple is also a variety targeted for intensive selection, but I obtained no viable seed in 2003 because of disease pressure, so I grew out the unselected strain again in 2004.

Selections of Cherokee Purple and Pruden's Purple from 2004 are again being grown out at Hampshire College for hand-crossing. Indian Moon and Green Zebra are also being grown out to cross with Cherokee and Pruden's, with the hope of developing resistance and then either selecting back to the original type or finding some interesting new color types. The timing and the lighting and fertilization program have been fine-tuned so that we have better hope of obtaining seed for 2005.

2004 Results and Discussion

Following are disease ratings for 2004 ranked from the least to the most disease:

Variety	Disease Rating	Relative Yield	Relative marketability
Indian Moon	3.23	High	High
Green Zebra	3.61	High	High
JTO-99197	3.67	High	Medium
Crimson Sprinter	4.87	High	High
Cherokee Purple unselected	5.75	Medium	Low
CP selected #1	5.18	Medium	Low
CP Selected #2	5.69	Medium	Low
Pruden's Purple	6.18	High	Medium

Ratings on a 1-9 scale with 1=least disease; three ratings performed in August and September 2004

Disease levels in general were lower in 2004, and *Alternaria* seemed to be more predominant. JTO-99197 did much better in relation to the other varieties and Pruden's Purple did relatively worse than in 2003, supporting the idea that Pruden's does better with Septoria than *Alternaria* and vice versa for JTO-99197. The first year of selection on Cherokee Purple did not show any better performance than the unselected strain. Better performance may have been seen if the selected Cherokee Purple plants had been crossed as planned. One Cherokee Purple plant showed atypical growth for the variety with less determinant vines, later and lower fruit production, and lower disease pressure. Though the late fruiting was not positive by itself, crossing this strain with other Cherokee Purple strains could be a promising avenue for disease resistance. Indian Moon and Green Zebra again performed very well in 2004; since I ran no comparison with unselected strains of these varieties, I do not know if selection improved their performance.

Economics

There is no immediate impact on my farm's bottom line, but if I am able in future years to develop stronger disease resistance, it would have a great impact on profitability.

Assessment

In the first two years of selection, I have identified two heirloom varieties with good disease resistance for *Alternaria* and *Septoria*: Indian Moon and Green Zebra. I have also learned a great deal about what characteristics make for better disease resistance. I have also identified varieties which most need improvement (Cherokee and Pruden's Purple) and made initial selections. Breeding and selection programs obviously take several years; I have applied to SARE to continue funding for this project. Along with further selection of Cherokee and Pruden's, I also plan to trial a broader range of pink and purple varieties to see if I can find one that has higher initial levels of resistance. There are a number of look-alike varieties for both Pruden's and Cherokee; an initial broad screening would have been a good first step for the project.

Adoption N/A

Outreach

I talked about this project at my two annual farm tours as part of the NOFA Summer Conference. ROS did not conduct Summer Seed Schools in 2003 and 2004; the NOFA tours were my substitute for those summer presentations. A Hampshire College class on seed-saving came to the farm to hear about the project in Fall of 2004. I plan to contact members of that class this winter to demonstrate hand-crossing in the greenhouse. I also presented a poster at the October 2004 SARE conference and a talk at the December 2004 ROS Winter Seed School. This report will be sent to UMass Extension, *Growing for Market*, and *HortIdeas* for possible publication.

Report Summary

The purpose of this project was to select heirloom tomato varieties for resistance to *Alternaria* blight and *Septoria* leaf spot. I planted six different varieties in a plot designed to have heavy disease pressure (the "disease nursery"), and selected the best-performing individuals from each variety. Seed from each of those individuals was then grown out in the disease nursery for re-selection in 2004. Indian Moon and Green Zebra were identified as already quite resistant to the disease. Further selection needs to be done to improve disease resistance in Cherokee Purple and Pruden's Purple.

Jeremy Barker Plotkin, January 18, 2005