

Title: Field Testing Of Resistant Tomato Lines to Control Late Blight and Early Blight in Conventional and Organic Growing Systems

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State(s) involved: NY and PA

Years funded: 3 years, 2005/2006 through 2008/2009

Funding amount: \$122,364

**B. Nontechnical Summary.**

The recent creation of tomato inbred lines possessing LB resistance and/or EB resistance created the opportunity to restructure integrated strategies for the control of these diseases. Prior work funded by USDA CAR has defined some of the parameters for a coordinated control strategy using the available resistance and control compounds. Integration of genetic resistance and reduce risk fungicides and biological controls are urgently needed. For the NE growers to use this approach, these resistant lines and strategies must also fulfill the needs of the shorter, cooler season characteristic of the NE growing regions. Our goal is to finalize the development of the tomato lines possessing resistance to LB and EB, then to test the best of these lines under traditional and organic growing systems. This work will result in the development of a coordinated total disease control program for NE tomato production using the genetic resistance to provide more reliable disease control and also significantly reduce reliance on chemical control.

**C. Introduction.**

Tomatoes are an important part of a diverse and balanced diet. One medium fresh tomato (135g) provides 47% RDA of Vitamin C, 22% RDA Vitamin A and 25 calories (135g). Tomatoes are rich in the anti-oxidant lycopene, a compound that protects cells from oxidants that have been linked to cancer.

Although greater production occurs in Fl and Ca, tomato is also an important vegetable crop in NE states, including NY, NJ and PA. The acreage in PA, NJ, and NY was 11,000 A with a value in excess of \$68 million during 2002 (USDA Statistics, 2002).

LB and EB have resulted in numerous epidemics of tomatoes throughout North America, causing considerable loss of yield and crop quality. In the NE in both 2003 and 2004, LB and EB were major problems for tomato production, and heavy losses were sustained. These diseases are a high priority for both NY and PA (see letters of support from NY and PA Vegetable Grower's Associations, and from individual growers and IPM Educators).

Presently, NE growers rely on multiple fungicide applications to achieve the current levels of disease control. New immigrant forms of *P. infestans* have introduced both metalaxyl-resistance and the capability of oospore survival, which will make LB disease management even more difficult. Chemical control measures can be an effective means of managing LB, and are usually guided by forecasts of blight-favorable weather conditions, but chemical applications are both time- and cost-dependent, and may be of reduced efficacy if weather conditions are particularly conducive for the disease. Similar fungicides used to control LB also control EB. Copper fungicides are used in organic fresh market tomato production; however, copper has been shown to only suppress late blight. Fungicide sprays add a

great financial burden to growers. In PA, for example, the average cost of each spray is about \$20 per acre, for a total of \$200 per season (average of 10 sprays per season). That adds up to over \$1,000,000 per year in just one state, which when extrapolated over the entire county, is a tremendous expense to growers, consumers, and to the economy. Recent research has also demonstrated the greater challenge of controlling EB disease caused by the light variant of *A. tomatophila*. All of these factors have generated considerable interest in alternative methods for LB and EB control.

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#### **D. Objectives.**

**Objective 1.** Identify appropriate LB and EB resistant lines for use in regional trials and possible release.

The NY breeding program has recently created 32 LB and EB resistant fresh market breeding lines, and 17 LB resistant processing tomato lines. The PSU tomato breeding program has also been developing fresh market as well as processing lines with improved EB resistance. Although these are not as advanced as the NY lines, they also should be evaluated for use in the Northeast. This abundance of material is advantageous, since it allows selection of the materials with optimal horticultural characteristics for the NE, but they are more than we could include in regional trials. Therefore a limited number of large trials will compare these lines to determine the best subset of lines for extended regional testing in year 2.

**Objective 2.** Test EB and LB resistant lines in regional trials to determine their performance and utility in traditional and organic systems.

The trials of the lines selected in year 1 are still ongoing as of 8/28/06. One alteration in the plans is that for the trials in 2007 we will expand to focus on hybrids that possess LB/EB resistance, and even better horticultural type through the combination of the parent of the hybrids. Seed for the year 3 hybrid trial will be generated in year 2.

**Objective 3.** Release materials and information to enable NE growers to use the new strategy.

The information generated by this work will be provided to extension personnel and growers through a variety of channels including publication or articles, and the web site <http://vegetablemdonline.ppath.cornell.edu/Home.htm>, presentations at demonstration days held at the research plots, and at stakeholder meetings in both states. The tomato lines will be released through appropriate channels to promote their use. Complete information will be provided to seed companies along with the releases to guide their use of the materials in developing and releasing varieties for use in NE. This objective will be accomplished year 3.

**E. Approach.** The approach is to use tomato lines or hybrids combining LB and EB resistance, and adaptation to conditions in the Northeast and to determine the best lines and the best use of these lines in control of LB and EB in Northeast tomato production under standard or organic practices.

#### **F. Progress.**

Year 1: In the first field season, all of the lines available were evaluated in trials in NY under standard and organic practice and PA under standard practice to determine the best lines to include in more extensive trials in the second field season. The trials were successful, and a subset of lines with confirmed resistance to LB and EB and the best horticultural characteristics were selected for testing in

year 2, and for creating hybrids to be tested in year 3. Therefore this objective has been accomplished

The results of the Early Blight trial confirmed that the Cornell lines were fixed for the early blight resistance. The results of this early blight trial also demonstrated the difference in the degree of disease control the resistance provides on stems vs. on the foliage. The stem ratings on all of the resistant lines are uniformly very low (from 0.0 to 0.2), in contrast to the ratings of the susceptible controls (>4.0). However foliar symptoms, as measured by the % defoliation on the last reading date (19 Sep) or by area under the disease progress curve (AUDPC), were not as well controlled as the stem symptoms. There was also considerable variation among the resistant lines for foliar disease development. This could have been due to differences among these lines for maturity and fruit load/development, rather than any true difference for resistance.

The results of the trials allowed the selection of lines with the best horticultural characteristics in addition to disease resistance. The better inbreds in terms of production, fruit size, as well as fruit characters such as shape, smoothness, blossom end scar have high production levels, though fruit size was smaller than that of the hybrids.

Year 2: A subset of LB/EB lines selected in 2005 was retested in 2006 in expanded trials in NY and PA summer 2006.

The establishment and initial growth of the trial plots in Ithaca was very favorable. Lines selected in 2005 were retested in 2006 in expanded trials. We also tested these lines in disease trials with modest input of chemical controls, in addition to the resistance, to extend control of foliar symptoms of early blight. The Freeville plot was inoculated with the light phenotype of the early blight pathogen, *A. tomatophila*, which is the most severe isolate of this pathogen. Data collection proceeded with readings starting with observation of first disease. The plots were later inoculated with the late blight pathogen as well. The disease screens resulted in the elimination of one line that was either contaminated or was still segregating for LB resistance. The trial confirmed the resistance of the other lines.

The 2006 season proved to be one of the wettest summers on record for Freeville, NY, with 19" recorded rainfall during the experiment. Early in the season, a heavy rain caused a nearby stream to start to overflow. The plot was not flooded, but the water table was nearly at ground level in parts of the plot. Wet soil conditions resulted in stunted plants, which especially occurred in small field depressions. Therefore we were not able to use the Ithaca trial to test for fruit characteristics and yield. Since plants were obviously severely stunted in major portions of the field, fruit and yield data would not have given valid results. Fortunately, the trial of some of the same lines on an organic farm near Albany provided a good evaluation of this subset of the lines at the Ithaca trial. Based upon the prior two years results, several of the lines were selected for production of experimental hybrids that will be homozygous for late blight and early blight resistance.

The trial performed under field conditions at Rock Spring, PA in the summer of 2006 tested a total of 14 fresh market breeding lines or cultivars, including 8 Cornell lines, 4 Penn State lines and two controls (LB-susceptible cv. Mt. Fresh Plus and LB-resistant breeding line NC96LB). The entries were grown in three replicates of 12 plants each. Throughout the season no inoculation was made for either early blight (EB, causal agent *A. solani* and *A. tomatophila*) or late blight (*P. infestans*). However, due to natural presence of the inoculum, there was uniform presence of EB throughout the 12-acre tomato plot. There was no incidence of LB. During September 2006, plants were visually evaluated in three different dates for the incidence of EB (% defoliation) as well as other horticultural characteristics. The AUDPC for the EB disease progression was calculated. Overall and comparatively, the materials developed at Cornell and Penn State exhibit good levels of EB resistance. The AUDPC tended to be lower indicating less disease in most of the Cornell lines. As is commonly observed, the intensity of EB development is highly dependent on fruit load and plant maturity, and greater disease expression could also be an indication of

plant with high yield and/or concentration of set for plant vine size. Higher AUDPC and disease could also be an indication of residual segregation for disease resistance, so uniformity of disease level should also be considered.

The lines selected based on the results summer of 2005 and 2006 were used in the winter of 2006/2007 for the production of hybrid seed. Crosses were generally successful, and the resulting seed will be used in trials summer of 2007. Most of these hybrids were generated in cooperation with Dr. R. Gardner of NCSU, and are the crosses of a Late Blight/Early Blight line from the Cornell program crossed with a Late Blight/Early Blight line from the NC program. Both sets of lines possess Late Blight/Early Blight resistances, but the two sets of lines complement each other for other important traits.

Year 3: The 2007 season is currently underway. The hybrids produced in the winter of 2006/2007 are being trialed in replicated trials in Ithaca, NY and near Albany NY. The trial will determine which of these hybrids possess both late blight and early blight resistances for utility and acceptability in this region, and acceptable horticultural type. These hybrids are being tested in CU plots in Varna, and demonstration plots are also in Freeville and at Geneva. Plants were also distributed to organic farmers who are grower-evaluators in the organic seed initiative administered at Cornell.

The majority of the hybrids being tested are fresh market determinate types. As described above, all of these hybrids were generated in cooperation with Dr. R. Gardner of NCSU, and are the crosses of a Late Blight/Early Blight line from the Cornell program crossed with a Late Blight/Early Blight line from the NC program. Since both parent were fixed for the resistances, these hybrids are also fixed for Late Blight/Early Blight resistance, and should have the highest level of control for both diseases. The hybrids are being examined in 2007 for fruit and vine type, and maturity, to determine which of them has the greater potential use. The advantage of the cross between the programs is that the lines complement each other for maturity and fruit size. Since this season was a bit cooler, there is only a modest amount of ripe fruit by late August. Harvest trial were delayed until September. Data collection will continue through September, and data will be collated and analyzed, and reports with complete results will be prepared once analysis is completed.

In conjunction with goal 3, the Ithaca trials were shown to seed company representatives in field day held Aug 26 and 27, 2007. Company representatives showed considerable interest in the hybrids, and have asked when seed of the lines will be released. Release will be in conjunction with annual report of the Cornell Vegetable Breeding Institute, Dec., 2007.