

Development and Assessment of Bacterial Wilt and Downy Mildew Resistant Cucumber Seedstocks (Year Two) - Final Report

by Edmund Frost

Please note - for data spreadsheets and supplementary reports associated with this project please visit: <http://commonwealthseeds.com/2019-cucumber-research-and-breeding-project-results/>

Introduction

Cucurbit downy mildew and bacterial wilt are central limitations for organic cucumber production in the Eastern US, that also seriously impact conventional growers. We have determined this through our experience as organic seed and produce growers, and from conversations with numerous growers, seed company representatives and educators at organic farming conferences.

Downy mildew is caused by a fungus-like organism called an oomycete. It overwinters in tropical and subtropical areas, and spores blow north on the wind each year, causing serious damage to cucumber and other cucurbit family foliage - by mid August most years in Virginia, sometimes as early as mid July.

A mutation in the pathogen occurred around 2004 that rendered possibly all previously resistant U.S. cucumber varieties much more susceptible. Since then there has been a strong need to identify sources of downy mildew (DM) resistance and to breed new commercial varieties. We have been working on this problem at Common Wealth Seed Growers since 2014, when we conducted a screening of USDA germ bank cucumber accessions at our farm (with help from a SARE grant). We then made a cross from three promising seedstocks – one from the Philippines, one from China and one from the U.S. We have been breeding and selecting from this population since, including in 2018, our first year of OFRF funding for this work.

We have also collaborated with Michael Mazourek of Cornell University for several years, evaluating and selecting DM resistant lines that he has bred, and producing and marketing seeds of two of these lines: DMR 401 and DMR 264. We believe it to be important to develop and work with multiple sources of DM resistance to increase options for growers and to increase resilience in the face of potential changes in the pathogen in the future.

Bacterial wilt (BW) is a disease that is transmitted by cucumber beetles, an insect native to North America. The disease starts at the leaves and travels through vines, killing them. We have found substantial variation in levels of resistance between varieties, and selecting/screening for resistance has become an important element of our cucumber breeding work.

2018 Project Summary

In 2018, with funding from OFRF, we did two variety trials at our farm in central Virginia – one focused on bacterial wilt and one focused on downy mildew. The trials included both cucumber and melon seedstocks. In the trials we found that our cucumber breeding lines showed good potential for resistance or tolerance to both diseases. We also conducted a breeding trial in order to make improved selections from our breeding lines. Over the winter of 2018-2019 we contracted with Jay Bost, a grower in Waimanalo Hawaii to increase seed of the best selections. See commonwealthseeds.com/research for the complete report.

2019 Project Elements, Results and Discussion

In 2019 we decided to work only with cucumbers (rather than melons) because of the potential our cucumber lines showed in the 2018 project. Our 2019 work included a bacterial wilt trial, late-planted downy mildew-focused breeding trials for both pickler and slicer lines, and collaboration with both university and farmer researchers on downy mildew-focused variety trials. Following are presentations of methods and results for each element of the work done in 2019.

Bacterial Wilt Trial - In 2019 we did a second bacterial wilt trial on our farm, laid out and evaluated the same as in 2018, although with changes in seedstocks. The trial included five 3-plant replications of each of 14 cucumber seedstocks, plus 7 seedstocks with fewer replications (due to limited seed availability of some breeding lines; seed dormancy of some breeding lines because the seed had just been harvested from winter increases in Hawaii; and seedling mortality). A central goal of this trial was to gather information on BW susceptibility of our lines to aid in making selections during our breeding trials (see below). We also wanted to see how our lines compared to commercial standards.

The trial was transplanted in the field in May 28th. We evaluated for bacterial wilt damage several times over the lifespan of the trial, rating plots on a 1-7 scale, with 1 indicating no damage, 2 indicating minimal leaf damage, 3 indicating more leaf damage, 4 indicating some spreading along vines, 5 indicating severe vine dieback, 6 indicating a plant killed by BW and 7 indicating all plants in the plot dead from BW. Plants were harvested but yields were not measured.

Results: [See Figure 1 for data.](#) Data for each variety is reported as a percentage of plots where BW spread along vines (having a rating of 4 or above at some point in the trial), and a percentage of plots where severe vine dieback occurred (having a rating of 5 or above).

All plots of all lines displayed some BW, with Bristol F1 and Citadel F1 displaying the highest occurrence of vine dieback (all plots) and Marketmore 76 displaying the highest occurrence of severe vine dieback (four out of five plots). This contradicts the results of the 2018 BW trial where Marketmore 76 was the least affected by BW. However, in line with the 2018 trial, the 2019 trial displayed a trend wherein the CWSG breeding lines had lower than average impact from BW. The only seedstocks in the 2019 trial that showed no severe vine dieback in any plots were CWSG lines, with seven out of ten lines showing no severe dieback. Moreover, lines 45x20+4 and 110x114 showed no vine dieback at all, pointing to them as good choices for BW resistance as we move forward with the selection process.

Downy mildew also appeared late in the trial, making it harder to attribute the cause of vine death in the last evaluation on August 17th. Accordingly, the rating for 8/17 is for overall foliage appearance rather than BW mortality. In this rating the CWSG lines continued to do well, as did DMR 401, Ghost in the Wind, and Bristol.

Pickler Breeding Trial – we grew and evaluated approximately 280 plants from seven pickling cucumber lines selected in 2018. The trial was transplanted in the field on July 18th. Plants were trained separately and evaluated for productivity (number of fruits harvested), overall vigor, impact of DM on foliage by early October, sweetness, flavor, shape, and % marketability. Yields and notes about fruit quality were recorded on flags placed at each plant. Sweetness was rated on a 1-5 scale (5 being sweetest). We also recorded notes about fruit shape, noted fruits that had especially aromatic flavor, and fruits that were especially crisp (and attempted to rate crispness from standout plants). We were able to save seeds from the best selections, including self-pollinated seed and seed from crosses between the best plants.

Results: [See Figure 2 for data.](#) About 25% of plants from line 30x48 yielded fruits with bitter stem ends. For this reason we rogued all plants from this line in late August, so do not have data about yields or DM resistance for them. Complete data was collected and reported for the remaining 222 plants.

Note that some (21) of the plants in the data sheet were direct seeded on July 18th rather than transplanted – resulting in later and lower yields. These plants are marked as “direct seeded” on the data sheet and are not included in the following comparisons and discussion.

Lines 45x20+4 and 110x114 overall showed the best DM resistance and yields, with two selections from 45x20+4 (plants 532 and 525) showing especially high yields (over 50 fruits per plant) and good DM ratings. There was some variation in the field in terms of fertility or potentially other factors, with blocks towards the southern end of the field tending to yield better. For instance, one block of plants from line 45x20+4 did better in terms of yields and DM ratings than a second similar block. However both blocks did better than, for instance, the two blocks from line 2x3. Plants from line 20x115 tended to be later than other lines, and plants from 110x114 tended to be earlier.

The pickler lines we are moving forward with in 2020 are derived mainly from line 45x20+4 (plants 532, 525, 536 and 546) as well as from line 110x114 (plants 134, 121, 128 and 110). We may choose to work with additional 2019 selections in the future, but we are not able to plant as large a breeding trial in 2020 as in the two previous years so we are honing in on a small handful of selections.

We also identified two plants in the pickler trial that had good slicing cucumber characteristics (plants 429 and 712) and are moving forward with these for developing slicing varieties.

Slicer Breeding Trial – we grew and evaluated approximately 100 plants from four slicer lines selected in 2018. We recorded notes and yields of standout plants in this trial on flags placed at each plant, but did not systematically record all yields in the trial. We were nevertheless able to identify and save seed from plants from line 27x12 that stood out for yields, flavor, crispness and DM resistance. We are moving forward with two of these selections in 2020, as well as a cross between them and plants from the pickler trial (429 and 712) that showed potential as slicers.

University Trials – we worked with researchers at University of Massachusetts and North Carolina A&T University, who included our lines in their downy mildew-focused trials. The U-Mass trial, conducted by Susan Scheufele, compared three of our slicer lines to Marketmore 76, a standard DM-susceptible slicer, and Bristol, a Seminis variety listed as DM resistant. DM pressure was somewhat lighter than average. The CWSG lines performed best in terms of having less DM on the foliage, but had lower yields. Ghost in the Wind, a slicer line that showed promise in our 2018 DM trial was also included, but it died of an undetermined disease. [See the results here.](#)

The NC A&T trial, conducted by Dr. Sanjun Gu, included nine CWSG lines, two DMR lines from Cornell (DMR 401 and DMR 264), two DMR varieties from Seminis (Citadel F1 pickler and Bristol F1 slicer), Ghost in the Wind, and two DM-susceptible varieties (Expedition F1 pickler and Marketmore 76 slicer). The Cornell lines had the lowest DM levels, both with 0.7 ratings on a 0-5 scale. Expedition (rating of 5.0) and Marketmore 76 (rating of 4.0), as expected, had high levels of DM on foliage, as did Bristol (rating of 4.3). The CWSG lines were all in the middle (DM ratings ranging from 1.7-3.7), with 45x20+4 having the least DM among them. This confirms the results of our breeding trial where 45x20+4 had the best DM ratings. Citadel had a moderate DM rating of 2.7, but the best yields. The CWSG lines in general had moderate yields. DM-susceptible varieties Marketmore 76 and Expedition had the lowest yields in the trial. [See the results here.](#)

Remote On-Farm Trials and Farmer Input – we worked with three Southeast farms who conducted DM trials as part of the project, and sent our cucumber seeds to eight farms for informal input.

Timothy Robb of Compostella Farm in Picayune, Mississippi, planted a late trial for DM evaluation,

but DM did not appear or impact the trial. Web worm, a pest we are not familiar with in Virginia, destroyed the foliage on most varieties shortly after production started.

Keith Marshall of Nourishing Acres Farm in Cedar Grove, North Carolina planted a late slicer trial for DM evaluation. Cornell line DMR 401 had the best yields and DM resistance, with a marketable yield of 4 pounds per plant and a DM rating of 2 (on a 1-9 scale) at the end of the trial. CWSG line 27x12 had the next best yield (3.7 pounds per plant) and the third best DM rating (5), after Cornell line DMR 264. DM-susceptible Marketmore 76 performed poorly, as did Seminis' DM-resistant variety SV4719CS – both were dead from DM by the end of the trial. The two replications of DM-resistant Bristol had moderate marketable yields (1.4 and 2.6 pounds per plant) and poor DM foliage ratings (8 and 9 at the end of the trial. [See Figure 3 for data.](#)

Jamie Yurgartis of Middleton Place Farm in Charleston, South Carolina, planted a DM trial in late May that was heavily impacted by damping off of seedlings. She replanted on August 10th, but this trial was destroyed by Hurricane Dorian on September 5th and 6th before yield or DM foliage ratings had been recorded.

We did not receive feedback from all of the farms we sent cucumbers to for informal assessment (some didn't manage to get them planted or had other problems before harvest). The feedback we did receive was positive, especially from Broadfork Farm of Chesterfield, Virginia:

(CWSG lines) “43x16F, 27x12 and 112x20 all tremendously outperformed other varieties in terms of late season Downy Mildew pressure... All three were spectacularly better than all other varieties we have tried as far as marketability, eating quality, and productivity... These cukes are stunning with their color, and super forgiving with their size. They are still very good when harvested too late. We love, love, love them. They meet all of our needs and wants for late season cukes.”

Outreach – we hosted a field day at our farm, and presented at two farming conferences (Carolina Farm Stewardship Association and Organic Agriculture Research Forum). The field day took place on September 19th and about 25 people attended. We gave an overview of the breeding project and presented some early results before going to walk around the breeding trial. We engaged participants by giving them flags to mark the plants that looked best to them. We also toured our butternut squash breeding trial (not funded by OFRF). *View the presentation given by Edmund Frost at Organic Agriculture Research Forum here.* Common Wealth Seed Growers has posted pictures and a preliminary report about the project on our website and in a print newsletter. We will be posting this final report on our website as well – see commonwealthseeds.com/research.

2020 and Next Steps Jay Bost of Waimanalo, Hawaii grew and increased seed supply for the best selections in our 2019 breeding trials. We planted an early observation plot of many of the lines this spring, and the picklers in particular are looking good in terms of shape, eating quality and BW resistance. Plants from our slicer lines are also doing well but there appears to be more work to do in terms of fruit shape and color.

We planted late breeding trials in July, approximately 170 plants total, which we will be starting to evaluate in late August or early September.

We sent seed samples out to about 15 farms that requested them and are looking forward to hearing more feedback. We also sent seeds to researchers who requested them at Ohio State, Cornell, and Johnny's Selected Seeds. We have small seed production plots of both pickler and slicer lines so that we will be able to distribute more seed for feedback next year.



Pickling Cucumber Breeding Trial



Fruits from Pickling Cucumber Breeding Trial



Edmund Frost, John Kimes and Dr. Sanjun Gu at the NC A&T Trial



Pickling Cucumber Breeding Trial