ORGANIC FARMING RESEARCH FOUNDATION

Project Report Summary

BREEDING FOR DISEASE MANAGEMENT IN TOMATOES

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Public breeding for organic agriculture: Screening horizontal resistance to late blight in tomatoes

Late blight (LB) of tomato and potato, caused by the fungal pathogen *Phytophthera infestans*, is currently the most destructive disease of tomato in the Pacific Northwest. Tomato researchers have reported an increase in both the virulence and prevalence of many new genotypes of the pathogen.

The importance of this disease increased substantially in the early 1990s when new clonal lineages of the A2 mating type migrated from the Toluca Valley of Mexico. Previous to this only genotypes of the A1 mating type had been detected outside of the Toluca Valley. The migration of the A2 genotypes (which are able to sexually mate with A1 genotypes, thereby creating new genetically recombinant genotypes) brought a sharp increase in the number of *P. infestans* genotypes in many environments where late blight is a problem.

In the Willamette Valley of Oregon, Western Washington, and Western British Columbia, most organic farmers will not attempt to grow a tomato crop in the field due to expectations of heavy losses from this disease. Growers either abandon tomatoes as a viable crop or grow the crop in high tunnels with much added expense.

A number of plant breeders improving crop varieties for the challenges of organic cropping systems consider polygenic, quantitatively inherited disease resistance or "horizontal resistance" (HR) to be appropriate for issues of sustainability in agriculture. Growing HR varieties establishes a more effective ecological balance in the field between the pathogen and host; the disease is able to survive but is present at manageable levels.

Previous work by John Navazio has identified several tomato populations known as Bellingham Late Blight Populations (BLBP) with moderate levels of blight resistance. The BLBP have gone through 3 cycles of selection for late blight resistance under heavy disease pressure. They also have early maturity, superior culinary quality and appropriate fresh market fruit type, all of which, coupled with late blight resistance, are important for organic fresh markets in the Northwest.

Above: Cull pile of unmarketable fruits with late blight symptoms 7-10 days after the initial disease outbreak.

Objectives

Our research goal is to quantify resistance to late blight by screening BLBP varieties under conditions conducive to the spread of the fungus *P. infestans*, and by collecting data in these field trial evaluations. We will use this data to make selections within the BLBP with the goal of developing open-pollinated varieties that will be publicly available to organic farmers and other tomato breeders.

Materials and Methods

This experiment was planted at Old Tarboo Farm (OTF) in Quilcene, Washington and The Evergreen State College Farm (TESCF) in Olympia, Washington. The field plot layout was a randomized complete block design with three replications using twelve tomato accessions (six cultivars and six breeding populations) as treatments. Accessions include five cultivars and six populations that had previously demonstrated some level of resistance to late blight.

The commercial tomato cultivars with purported resistance to late blight included 'Legend', Juliette', 'Slava', 'Stupice', and 'NC03220'.

Results and Discussion

By 2 August the first disease lesions were discovered on several accessions in the TESCF plot. Samples were taken and subsequently confirmed to be early blight (EB) (*Alternaria solani*). Although we had not intended to evaluate the progression of EB, we observed considerable variation between accessions in these plots for disease symptoms to this malady and decided to score for levels of resistance until LB appeared.

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Project Notes

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Project locations: Old Tarboo Farm, Quilcene, WA and The Evergreen State College

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Late blight results: At OTF the disease did not spread through the field in an even fashion, thereby eliminating any chance of recording accurate data on the relative resistance to disease. At TESCF the spread of the disease was even but the rate at which LB spread through the experimental plot was too rapid to allow for more than two weekly readings. This outbreak at TESCF was the most rapid and severe sweep of this disease in a tomato field that Dr. Navazio has ever witnessed.

From the Kruskal-Wallis test for non-parametric data we get a clear indication that 'NC 03220' (11), 'Juliet' (7), and 'Stupice' (10) are more resistant to LB than other accessions in the test.

The disappointing showing from Bellingham Late Blight Population (BLBP) accessions for LB resistance in this experiment might be explained by the extreme aggressiveness of the pathogen in comparison to the *P. infestans* isolates that these accessions had been selected for resistance to in Bellingham.

However, there was variation in resistance to LB that is not revealed in the data means as reported. Individual plants of 'BLBP-1' (1) and 'Legend' that had considerably more resistance to LB in this test than the population mean were used to make hand-pollinated crosses with these "more resistant" individuals (within and between populations). Individual plants were marked and seed was saved from these resistant plants (tomatoes are primarily naturally self-pollinated) as new breeding stock.

Early blight results: The appearance of EB in our plots was unexpected and initially viewed as a potential hindrance to our work with LB. Three standout accessions scored highest for resistance in both tests, 'BLBP-1', 'Juliet', and 'NC 03220'.

Conclusions

This experiment was successful in demonstrating that there exists tomato germplasm that has levels of resistance to a very pathogenic genotype of LB under field conditions. Resistance to the US-11 genotype of late blight was found in both 'NC 03220' and in 'Stupice' which has a significant level of HR to LB. 'Juliet' was also resistant. 'NC 03220' and 'Juliet' were extremely late maturing in western Washington, which is a serious hindrance to their use as breeding stock for the Northwest. 'Stupice', however, is well adapted to the Northwest's short growing season and has a consistent and early yield of 2 to 3 ounce fruits. It exhibited considerable genetic variation for HR, fruit shape, and flavor and would be an excellent population to select within for increased HR and superior quality attributes.

In evaluating for HR, it is very important to monitor how the purportedly resistant plant holds up to disease pressure and if the resistance is able to significantly slow the progress of the disease over time. Therefore in future LB work in the field we will collect data on a much more frequent schedule to assure a more accurate appraisal of the progression of disease which will translate into a more robust statistical analysis.

This experiment also successfully identified a range of materials that are resistant to EB. Among the most resistant were 'NC 03220' and 'Juliet' which were also at the top for LB resistance. 'NC 03220' showed little or no EB symptoms through the duration of the experiment. But both 'NC 03220' and 'Juliet' were much too late maturing in the coastal Northwest. Several BLBP accessions did have significant resistance to EB, notably 'BLBP-1', which also has HR for LB and will be selected for resistance to both diseases in future experiments.

Through identifying the most resistant segregants for HR to LB from among the best parental stock that we have identified it is certainly possible to increase the quantitative levels of this resistance among the subsequent generations of the tomato germplasm we are breeding. If we can indeed couple this resistance with HR for EB in suitable fresh market tomatoes in subsequent experiments then we will be on task in supplying organic farmers in the Northwest with tomato varieties that can be produced in the field. ❧

Above left: Experimental hybrid from North Carolina State University showing early stages of symptoms. This hybrid had the greatest measurable resistance, but was very late in maturing compared to other accessions. **Above right:** Stupice, although showing resistance in a number of plants was not uniform in its resistance response. These susceptible segregants show disease stages in different stages of fruit development.

Kruskal-Wallis test for mean late blight at TESCF. Treatments 11, 7 and 10 were significantly resistant to late blight compared to the population.

Treatment	N	Median	Mean Rank	Z
11	3	8	33.8	2.63
7	3	5.5	23.8	0.92
10	3	6	21.5	0.52
8	3	4.5	20.3	0.31
9	3	5	18.8	0.06
4	3	5	17.5	-0.17
5	3	5	16.7	-0.31
2	3	4.5	15.8	-0.46
1	3	4.5	15.5	-0.52
3	3	4	13.8	-0.8
6	3	2	12.3	-1.06
12	3	3	12	-1.12
H = 11.85, DF = 11, P = 0.456 (when adjusted for ties)				