Tomato Genetics and Breeding Research at Penn State

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The major focus of the Penn State Tomato Genetics and Breeding Program is to develop breeding lines and cultivars with improved early blight (EB) and late blight (LB) resistance and with high fruit lycopene (LYC) content. EB, caused by the fungi Alternaria solani and A. tomatophila, and LB, caused by the oomycete Phytophthora infestans, are two most common and destructive foliar diseases of the cultivated tomato (Solanum lycopersicum) in the northeast U.S. and many other places in the world. While EB infection is usually associated with plant physiological maturity and fruit load, LB can infect and devastate tomato plants at any developmental stages. Cultural practices and heavy use of fungicides are currently the most common measures for controlling EB and LB. Genetic sources for resistance to both diseases have been identified largely within the tomato wild species S. pimpinellifolium and S. habrochaites. We have studied genetic controls of EB resistance using different interspecific populations of tomato. EB resistance does not follow the gene-for-gene interaction model, as no major resistance gene has been identified and there is no pathogen race specificity. Sources of genetic resistance in S. habrochaites were previously utilized in traditional breeding, resulting in lines and cultivars with moderate resistance. We have identified and utilized resistant accessions within S. pimpinellifolium and developed fresh-market and processing tomato inbred lines and advanced germplasm with improved resistance to EB. For example, recently we released several FM inbred lines of plum, cherry and grape tomatoes with improved EB resistance for commercial evaluation and development of hybrid cultivars. Inbred lines of processing and large size FM tomatoes with improved EB resistance are in the pipeline. However, development of high-yielding tomato cultivars with early maturity and high resistance to EB remains a challenge. We also have identified QTLs for EB resistance in both S. habrochaites and S. pimpinellifolium, which could be used for MAS breeding. As to LB, a few race-specific major resistance genes (Ph-1, Ph-2 and Ph-3) and several race-nonspecific resistance QTLs were previously reported. Ph-3 is considered a strong resistance gene and has been incorporated into several fresh market and processing tomato breeding lines. New P. infestans isolates have been identified which overcome Ph-3 resistance. Recently, we have identified and mapped a new LB resistance gene, Ph-5, which confers resistance to several pathogen isolates including those which overcome the previous resistance genes. We have developed inbred lines of cherry and grape tomatoes with Ph-5 resistance and inbred lines of processing and large-size FM tomatoes with Ph-5 resistance are in the pipeline. Currently we are fine mapping Ph-5 toward its map-based cloning. We also are developing FM and processing tomatoes with different LB resistance genes combined. As to fruit LYC content, we have identified new genetic sources of high LYC and mapped QTLs for this trait. This high LYC trait is not associated with any undesirable horticultural characteristic in tomato. We have focused on fine mapping of two QTLs, in particular a QTL on chromosome 12 (lyc12), where we have mapped it within 1-few cM. We have developed NILs with lyc12 in the background of the cultivated tomato. We also have developed FM and processing tomato inbred line with exceptionally high fruit LYC content. A few of these lines were recently released and more are in the pipeline.