Predicting and Managing Invasiveness of the Q Biotype of the Sweetpotato Whitefly
2008 IPM Grant Report

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Project Objectives: The overall goal of the project was to explore conditions that could affect invasiveness of the Q biotype of the whitefly *Bemisia tabaci*. Although this pest has only been found in greenhouses and plant stores in the US to date, the potential invasion of the Q biotype into field production systems, including cotton, melons, and vegetables, represents a serious threat to crop production in Arizona and the US. Our work has focused on competition between the B and Q biotypes of *B. tabaci*, as such interactions could be key to understanding the potential impact of this new pest and for developing effective monitoring and prevention efforts. In addition, data collected could aid in developing IPM programs for the Q biotype if and when it invades field crops.

Activities / Outputs:

- Funds were used to conduct experiments to understand factors that could affect the establishment and spread of the Q biotype of *B. tabaci*. Specifically, we:

  1) Measured key life history traits for the Q biotype, including developmental time, fecundity, mortality, and offspring sex ratio. Similar data was collected for the B biotype.
  2) Conducted laboratory and population cage experiments to determine the outcome of competition between the B and Q biotypes of *B. tabaci* under various conditions.
  3) Performed behavioral observations to understand mechanisms by which the B and Q biotypes compete through reproductive interference, which is competition associated with mating and reproduction.
  4) Conducted bioassays to determine the susceptibility of populations of the B and Q biotypes to pyriproxyfen, a key whitefly insecticide used in Arizona.
  5) Determined if insecticide treatments with pyriproxyfen affected competition between the B and Q biotypes in population cage experiments.
  6) Developed mathematical simulation models to predict conditions under which the Q biotype could outcompete the B biotype. Models were developed using data from the laboratory, population cage, and behavioral experiments. These models determine the outcome of competition with the B biotype of *B. tabaci* under various conditions in laboratory and population cage experiments, and the relative importance of key factors on the establishment and spread of the Q biotype in Arizona.
  7) Formed collaborations with scientists in Australia and China to gain a global

perspective on whitefly invasions.

Outcomes / Current Status

Short Term Outcomes: Understand key factors that could affect invasiveness of the Q biotype of B. tabaci using laboratory experiments and simulation models.

1) Fecundity, mortality, and offspring sex ratio did not differ between populations of the B and Q biotypes on cotton. Thus, these factors may not be significantly affect invasions by the Q biotype. However, the B biotype develops significantly faster than the Q biotype, which could contribute to this biotype outcompeting the Q biotype in the field.

2) In laboratory experiments, the B biotype significantly outcompeted the Q biotype in terms of the ability of females of both biotypes to reproduce under competitive conditions. B biotype females exhibited flexible mating behaviors and were able to maintain production of viable female offspring despite competition from the Q biotype. In contrast, the reproductive ability of Q biotype females was reduced significantly due to competition from the B biotype. Models suggest that these differences limit the ability of the Q biotype to compete with the B biotype, and may partially explain the failure of the Q biotype to establish in field crops in the US. Our models, developed from data from our behavioral observations, were able to precisely predict the outcome of these laboratory experiments. This indicates that mechanisms we have identified in this study could be used to predict invasiveness of the Q biotype in areas where competition with the B biotype is common.

3) In population cage experiments initiated with 50% of each biotype, the B biotype displaced the Q biotype in five or fewer generations regardless of whether pyriproxyfen was used. In cages not treated with pyriproxyfen, the rapid displacement of Q biotype populations was expected and predicted with our simulation models. However, the B biotype also outcompeted the Q biotype even when pyriproxyfen was used. Laboratory bioassays indicated that low levels of resistance in B biotype populations allow them to survive and evolve resistance to pyriproxyfen treatments, and the surviving populations were able to outcompete the Q biotype.

4) We have recently acquired a new strain of the Q biotype, collected by the laboratory of Dr. Xianchun Li, and will be acquiring a second new Q strain from France in the coming months. Additionally, we are acquiring a new strain of the B biotype. Experiments conducted with these strains can help elucidate if the factors identified above are broadly applicable for populations of the B and Q biotypes.

5) One manuscript resulting from the research is under consideration in Behavioral Ecology. Two additional manuscripts are in preparation.

6) Results from the research were presented at the Annual Meeting of the Entomological Society of America in Reno, NV.

7) Preliminary results of the research were provided to members of the Cross Commodity Research and Outreach team.
8) We will continue to make all research results available with members of APMC to facilitate broad dissemination of the studies.

Medium Term Outcomes: Understand key factors that could affect invasiveness of the Q biotype of B. tabaci over a broader landscape.

1) Collaborators in Israel, Australia, and China have collected similar data from population cage experiments and behavioral observations involving whitefly biotypes. We are currently working with these individuals to determine if our models can predict the outcome of competition and invasions between *B. tabaci* biotypes over a broader range of conditions. Preliminary work has indicated general agreement between model predictions and observed results, indicating that we have been successful in identifying key factors that could affect invasiveness of whitefly biotypes.

2) We have received a large dataset of field-collected data on the distribution and spread of populations of the B and Q biotypes in Israel from 2003-2007, a country where both biotypes coexist. We are currently using this expansive dataset to explore conditions that affect competition between the biotypes in the field. Factors we will investigate include climate, host plants, insecticide use, and dispersal. We are developing statistical and modeling tools to analyze this dataset in the coming months, which will greatly aid in our ability to predict conditions that could affect invasions in Arizona and the US.

Long Term Outcomes: Develop new tools for predicting the impact of invasive pests.

1) We have developed novel methods to explore competition between closely related native and invasive species using experiments and mathematical simulation models. This powerful framework can be applied to predict invasiveness in other pest complexes and to determine the potential impact of invasive pests on native species.

Leveraged Resources:

1) The full amount received from the APMC ($10,000) was applied towards research described above. Approximately $5500 was used to cover salary and fringe benefits for David Crowder, a postdoctoral researcher who conducted the experiments and developed the models. The remainder of the funds were used for colony maintenance, experimental supplies, and greenhouse space.
2) David Crowder received additional salary support to conduct the experiments through fellowships provided by the Environmental Protection Agency STAR (Science to Achieve Results) program and from the Phoenix chapter of the ARCS (Achievement Rewards for College Scientists) Foundation.

3) The salary of Rami Horowitz, who assisted with the experiments and is providing the data from Israel, is provided by his organization while he is on sabbatical at the University of Arizona.
4) Yves Carriere has leveraged funds from other federal grants to aid in paying for colony maintenance, David Crowder's salary, travel to present results from the research, and experimental supplies.

Continuing Need

- Although we have made significant progress on identifying factors that could affect invasiveness of the Q biotype in Arizona, much work remains to be done. Continued funding from programs like the APMC IPM Program can make these goals attainable in the near future:

  1) Complete analysis of Israel dataset to identify factors affecting competition and coexistence between the B and Q biotypes in the field.
  2) Use results to predict of areas of greatest risk in Arizona and the US. Combine models already developed with geographical information systems (GIS) technologies to improve our prediction and monitoring capacity.
  3) Analyze factors affecting competition on a greater variety of host plants and environmental conditions.
  4) Continue research with new B and Q biotype strains recently acquired.