Onion thrips population genetics and implications for management.

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Onion thrips, *Thrips tabaci*, is the major pest of onion in New York where around 10,500 acres of onion valued between $40-60 million are grown annually. Onion thrips feeding damage can cause yield reductions of 30-50%. In addition, onion thrips transmit *Iris yellow spot virus*, and the damage caused by their feeding can enable secondary pathogens to infect the crop. Insecticides are the primary tool used to manage onion thrips, and are very effective at reducing populations. However, past lessons with pyrethroid resistance highlight the importance of using these products only when necessary, and rotating different chemistries to delay development of insecticide resistance in these populations. An insecticide resistance management (IRM) plan has been developed by Brian Nault at Cornell University that outlines which insecticides to use, and how many times to apply a single active ingredient before switching to another that belongs to a unique class of chemistry. The goal of using this approach is to expose each generation of thrips that develops over the growing season to a single active ingredient so that resistant individuals don't persist to cause damage and produce resistant offspring. This approach should work because even if individuals become resistant to one class of compounds, they are not likely to become resistant to two or more classes of compounds. Therefore, any individuals surviving applications of the first insecticide class should be killed by applications of the second class of insecticides.

Figure 1. Onion thrips, *Thrips tabaci*

While chemical rotation is a very effective way to delay insecticide resistance, there are several factors that could interfere with the effectiveness of this strategy for onion thrips in New York onion fields. The first has to do with determining the scale at which we need to conduct these IRM plans. To ensure that resistant offspring don't persist, an IRM plan must be implemented at a scale that corresponds to the area inhabited by a population of onion thrips, i.e. according to how far onion thrips travel to reproduce. The second has to do with characteristics of the onion thrips populations themselves, which may complicate how we define populations – unknown dispersal capabilities, and the possibility that there are actually two "species" of onion thrips in New York. In order to answer these questions, we are using genetic approaches to look at relatedness of onion thrips across different onion production regions in New York. **In this article we describe the importance of the information gained from population genetic methods to determine the scale at which effective, long-term onion thrips IRM plans should be implemented for New York.**

The importance of spatial scale in IRM programs: Rotating insecticides from different classes is an effective way of delaying insecticide resistance from developing in pest populations. Problems with this strategy occur when there is non-compliance or uncoordinated efforts by growers occurring in areas inhabited by the same insect population. As an example of non-compliance, imagine two onion fields, A and B, planted next to each other but managed by different growers. Grower A implements a chemical rotation IRM strategy, whereas grower B always sprays the same insecticide. In time grower B will end up selecting for insects that are resistant to the insecticide being used, and will suffer crop losses. In addition, it is likely that resistant insects from field B will end up in field A because the distance between the fields is small enough that insects can move between them. Depending on the severity of the insecticide resistance problem (the number of resistant individuals surviving and moving between fields) and the timing of the movements in relation to grower A's chemical rotation strategy, grower A might suffer crop damage because of neighbor B not implementing an IRM strategy.

In the example of uncoordinated efforts, where farmer A and B would both be implementing chemical rotation strategies, the development of insecticide resistance in either field would not be as quick as in the previous scenario, but still would be faster than a scenario where insecticide rotation efforts were coordinated. In this scenario, insecticide resistance problems occur when timing of insecticide sprays and/or sequence of chemical rotations is different. Keep in mind that insects move freely between these two fields during the growing season. If the chemical rotation sequence is the same, but timing of insecticide applications is different, then this creates a lag where there is more time for resistant individuals to survive in the fields before they are killed by the next chemical class applied. Similarly, if the timing is coordinated, but the chemical rotation strategies differ, and grower A sprays the same chemical class grower B just finished spraying, then this allows more opportunity for resistant individuals to survive, reproduce, and damage the crop.

Although these examples are between neighboring fields, these scenarios could potentially be playing out over longer distances, the limits of which are as large as the dispersal capabilities of the insects. This question of distance is especially important in New York onion muck production areas because many of the mucks are isolated from each other by various distances, and in over half of the state, mucks are surrounded by non-agricultural landscapes. This means that farmer A and B only have to coordinate their efforts if thrips are actively moving between their fields, which may or may not be happening depending on where their mucks are located. Unfortunately, answering this question is difficult because thrips are small and hard to observe, and therefore, little is known about their dispersal abilities. We do know they are capable of moving between neighboring fields, which is likely to be important in larger muck regions in Elba and Orange Counties where fields are close and managed by different growers. This also may be important in areas where isolated mucks are separated by short-distances. In addition, we know thrips can disperse long distances on wind currents; however, we don't know how far they travel or how often this occurs.

Using genetic tools to better understand onion thrips populations: One way to investigate movement of individuals without directly monitoring them is to use genetic tests to determine whether or not thrips from different mucks are related to each other. Just as people can send off a sample of their DNA to discover information about their ancestry, family trees, or paternity, similar tests have been developed to examine the relatedness of insects. Some tests can provide information about the population structure of thrips, which is equivalent to determining whether they belong to the same family. If thrips are moving between mucks A and B then genetic tests will show that individuals collected at these locations are genetically related to each other. This information can then be used to determine whether IRM plans targeted against onion thrips in New York need to be coordinated at local (e.g., field to field) or regional scales (e.g., muck to muck).

Another important question under investigation that could have implications for IRM is: are there one or two "species" of onion thrips in New York? Previous studies have provided evidence for up to three "species" of onion thrips that look identical but behave differently, two of which have been found in New York. This theory is based on onion thrips populations having different ancestries (based on DNA), reproductive behavior (asexual or sexual reproduction), host plant preferences, and abilities to transmit a plant virus. What remains to be investigated is whether these differences are due to there being different species of onion thrips (different organisms that no longer interbreed, and therefore, have different characteristics), or are due to population-level differences (they have different traits because they are from different families, and these traits could spread to other families). If there are different species of onion thrips, this means they need to be examined separately with regards to IRM because they could differ in characteristics related to insecticide resistance. If onion thrips only belong to different families, then their differences will be accounted for when we determine how far individuals travel to reproduce. Until recently, we did not have genetic tests available to look at population-level associations among onion thrips. Now that we do, we can determine whether these are different populations or different species to ensure we have all of the information about onion thrips we need to develop effective, long-term management strategies.

Current research underway: Using a combination of tests that detect ancestral- and population-level genetic differences, we are currently in the process of examining the genetic relationships of onion thrips collected from onion mucks across New York. Onion thrips were collected both early- and late-season at nine mucks to look at population structuring within growing seasons over a two-year period. By doing this we hope to better understand if onion thrips populations are isolated in different mucks, or if they disperse to surrounding areas, and if so, how far they travel. This information will be used to help develop IRM plans that will be more effective at delaying the development of insecticide resistance in onion thrips populations, and increase the longevity of the few effective chemical options that exist for onion thrips control in onion.

Figure 2. Map of areas where New York onion thrips were collected from onion mucks.