Agronomic Spotlight

Seminis grow forward

Resistance Breaking Strains of TSWV in Tomato

- Strains of the Tomato spotted wilt virus (TSWV) can overcome the most commonly used resistance gene for TSWV in tomato.
- Resistance breaking strains of TSWV have been detected in several tomato growing regions of the world.
- Alternative strategies for managing resistance breaking strains of TSWV are being investigated.

Tomato Spotted Wilt

Tomato spotted wilt (TSW) [the disease], caused by the Tomato spotted wilt virus (TSWV) [the pathogen], has historically been found in the tropics, but TSW has been occurring with increasing regularity in more temperate regions. The disease was found on tomato in Hawaii in 1920, but since the 1990s, epidemics of TSW have occurred in tomato growing areas of the southeastern U.S. and California.[1,2]

Figure 1. Foliar symptoms of tomato spotted wilt virus (TSWV) infecton of tomato.

Symptoms of TSW on tomato start with a bronzing of young leaves, followed by the formation of small dark spots (Figure 1). Tip dieback, one-sided growth, and stunting of plants can also occur. If plants are infected early, they may not produce fruit; while fruit produced on later infected plants develop chlorotic ringspots with concentric rings (Figure 2).[1]

TSWV has a wide host range, infecting over 800 plant species in 80 different families. Many vegetable crop and weed species are susceptible to TSWV, and weeds often serve as reservoirs of inoculum. The virus is transmitted by several species of thrips, most commonly by the western flower thrips.[1]

Management strategies for TSW include the use of reflective mulches, controlling weed hosts, rouging infected seedlings, and avoiding planting near TSWV infected crops. Insecticide applications can help slow the spread of the disease. The most effective management strategy has been the use of tomato cultivars with resistance to TSWV.[1,2,3]

Genetic Resistance to TSWV in Tomato

Resistance to TSWV was found in wild relatives of domestic tomatoes, and some of these resistance genes have been moved into commercial tomato lines.[4] The *Sw1a* and *Sw1b* genes were quickly overcome by TSWV strains shortly after they were deployed. *Sw-6* and *Sw-7* provide partial resistance to a narrow range of TSWV isolates, but they are not well characterized and not widely used in commercial tomato lines. The *Sw-5* cluster of genes includes *Sw-5a* through *Sw-5e*, but only the *Sw-5b* gene conveys effective resistance to TSWV in tomato.[5]

The *Sw-5b* gene, most commonly referred to as just *Sw-5*, is the most widely deployed resistance gene for TSWV in tomato. It not only confers resistance to TSWV but also resistance to a several related viruses including Tomato chlorotic spot virus (TCSV) and Impatiens necrotic spot virus (INSV), which is unusual for a virus resistance gene.[5]

Figure 2. Symptoms of TSWV infection on tomato fruit.

Resistance Breaking

A greenhouse study in the late 1990s used a set of TSWV isolates from Australia to show that resistance breaking (RB) strains of TSWV could be induced by the selection pressure of using tomato varieties with *Sw-5* resistance.[6] The first detection of resistance breaking of *Sw-5* in the field was reported from South Africa back in 1993, but that RB strain of TSWV did not become established and did not spread.

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In the Barcelona region of Spain in 2003, tomato cultivars with *Sw-5* resistance developed typical TSW symptoms, and the presence of the virus was verified through lab tests. In this case, the RB strain of the virus became established and spread widely throughout northeastern Spain.[7] RB strains of TSWV have also become established in southern Italy in 2004, in the Central Valley of California in the spring of 2016, and in several other locations around the world.[8,9]

In the 2016 epidemic in California, disease incidence levels of 30% to 50% were documented in some fields early in the season, later reaching levels of 50% to 80%. The TSWV isolates collected from symptomatic plants could infect and cause symptoms on all of the *Sw-5* resistant tomato varieties tested in greenhouse trials, verifying the existence of RB TSWV strains in California.[9]

The emergence of RB isolates of TSWV in many locations worldwide most likely is the result of the continuous, widespread use of tomato varieties with *Sw-5* resistance.[5] At least some of the RB isolates of TSWV studied so far appear to have lower environmental fitness when compared to non-RB strains, because the percentage of TSWV isolates that are able to break *Sw-5* resistance declines over time in a region when tomato varieties with *Sw-5* resistance are not grown consistently in that region.[5] For example, tomato growers in Hawaii stopped using varieties with *Sw-5* resistance to TSWV because that form of resistance was no longer effective due to the presence of RB strains of TSWV. After several years of not planting *Sw-5* resistant varieties, the RB strains of the virus were no longer detected, and plants with *Sw-5* resistance were once again effective for controlling the disease.[4]

Complicating Factors

The appearance of TSW symptoms on tomato plants with *Sw-5* resistance is not always the result of the presence of RB strains of TSWV. Other factors can affect the expression of resistance. For example, mixed infections of TSWV and some other viruses, such as Tomato chlorosis virus (ToCV), have been shown to interfere with the expression of TSWV resistance.[5] Also, resistance does not appear to be expressed as effectively in blossom and fruit tissues as it is in leaf tissue. There have been reports of TSW symptoms developing on the fruit of TSWV resistant plants, especially late in the season. A study undertaken to determine why this occurs showed that virus-infected thrips feeding on blossoms and very young fruit resulted in TSWV infection of tomato varieties with and without the *Sw-5* resistance gene, leading to the conclusion that the gene is not expressed in the reproductive tissues.[10]

Search for New Resistance Genes

Finding new sources of resistance to TSWV is important to most tomato breeding programs, and collections of wild *Solanum* species are currently being screened for resistance to TSWV and other related viruses. A new version (allele) of the *Sw-5b* gene has been found that confers resistance to the common RB strains of TSWV in southern Italy, and it appears that other TSWV resistance genes are present in wild *Solanum* species that are as effective as *Sw-5*. So far, none of these genes are available in commercial tomato varieties. The use of genes that convey partial resistance could also be useful, as this type of resistance tends to be longer lasting.[4,5]

Other Approaches

Because RB strains of TSWV appear to be less fit than wild-type strains, the use of "*Sw-5* rest periods", times in which *Sw-5* resistant tomato varieties are not grown in a region, could be used to lower the proportion of RB strains and restore the effectiveness of the *Sw-5* resistance gene. There is some evidence to support the usefulness of this strategy. *Sw-5* resistance tends to be more effective in regions where resistant varieties are used seasonally, only when TSW epidemics are most likely to occur, as compared to regions where resistant varieties are grown continually.[4] Susceptibility to TSWV is also affected by plant age. In plants with or without *Sw-5* resistance, plants become less susceptible to infection with age. Therefore, finding management strategies that focus on preventing early infection could be very useful.[10] One other strategy that is being investigated is grafting tomato plants on to TSWV resistant root stocks, which has shown promise.[5]

Sources:

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For additional agronomic information, please contact your local seed representative.

Performance may vary from location to location and from year to year, as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible and should consider the impacts of these conditions on the grower's fields. The recommendations in this article are based upon information obtained from the cited sources and should be used as a quick reference for information about tomato production. The content of this article should not be substituted for the professional opinion of a producer, grower, agronomist, pathologist and similar professional dealing with this specific crop.