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Race Against Time

California's canning tomato industry weighs management options for Fusarium wilt race 3

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During the last five years, Fusarium wilt race 3 has moved quickly into all of California's major tomato-producing counties, including Fresno County where about 40% of the state's processing tomato production takes place. What actions can growers take to fight the disease? Earn 0.5 CEUs in Integrated Pest Management by reading this article and taking the quiz at www.certifiedcropadviser.org/certifications/self-study/828.

Fusarium wilt race 3 is nothing new to California's canning tomato industry. This latest variant of the fungal tomato pathogen, *Fusarium oxysporum* f. sp. *lycopersici,* was first detected in California three decades ago in the Sutter Basin of the Sacramento Valley. Race 3 was preceded by race 2, a form of the pathogen that was widespread in the Sacramento and northern San Joaquin valleys at the time. Yet, for years, race 3 remained localized to the Sutter Basin, and relatively few growers had to contend with it.

That's now changed. During the last five years, race 3 has moved quickly into all of California's major tomato-producing counties, including Colusa, Yolo, San Joaquin, Sacramento, and Merced. What has the industry most concerned, however, is that it recently reached Fresno County in the southern San Joaquin Valley.

"Fresno County is where about 40% of California's processing tomato production is concentrated," says Gene

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Opposite page: The telltale sign of Fusarium wilt in tomato is a yellowing of leaves and stems. Sometimes only one branch or side of a plant is affected, creating a "yellow flag" effect. **Right:** A dark brown vascular discoloration (from crown) extends far up the stem. Photo courtesy of Hung Doan, UC-Davis.

Miyao, a farm adviser with University of California (UC) Cooperative Extension in Woodland. "So when we get some movement of the disease into that area, people get excited."

The good news is that while earlier tomato varieties bred to resist race 3 suffered from soft fruit and lower yields, "a small but increasing number" of race 3-resistant processing tomatoes are now available that can match the yields of standard varieties, says Brenna Aergerter, a UC Extension adviser in San Joaquin County. Trials performed by her, Miyao, and others have also revealed several varieties that can tolerate race 3. "They're still susceptible to the disease," Aergerter says, "but the severity of symptoms is lower, and there's much less impact on yield."

Although tomato processors, not farmers, usually dictate which varieties get planted, she adds, growing tomatoes with resistance or tolerance to Fusarium wilt remains among the simplest, most effective ways to combat it. At the same time, new research and outreach efforts are under way to address a larger, longer-term worry.

"I think everybody at this point acknowledges that Fusarium wilt race 4 is a very real possibility," says Cassandra Swett, a UC Extension specialist in plant pathology at the University of California–Davis. "It doesn't exist yet, that we know of. But all it takes is enough time and a big enough pathogen population, and we'll have a new race that will overcome the resistance we've developed to race 3."

Complex, resilient pathogen

The fungus that causes Fusarium wilt, *F. oxysporum*, has a complex pathology. Several subspecies exist, each of which brings about disease in a specific host crop. The subspecies *lycopersici* causes wilt exclusively in tomato while *F. oxysporum* f. sp. *vasinfectum* afflicts cotton. Still other subspecies attack potato, eggplant, and pepper.

But the many subspecies of *F. oxysporum* can also survive inside a wide variety of crop plants without causing disease. The root cortex of tomato, for example, can host several *Fusarium* strains (and other fungi, for that matter). Yet, only one—the subspecies *lycopersici*—triggers disease by growing beyond the root cortex and into the water-conducting tissue, or xylem.

Once this happens, the pathogen is quickly transported throughout the plant and its growth begins blocking water movement upward from the roots, causing wilting. The telltale sign growers look for is a yellowing of tomato leaves and stems. Sometimes only one branch or side of a plant is affected, creating a "yellow flag" effect (see image opposite page).

While all three races of Fusarium wilt of tomato—1, 2, and 3—cause this same disease, tomatoes that can resist earlier races may still succumb to a new one. This has been the problem with race 3. When it emerged, it overcame the resistance to race 2 bred into commercial processing tomatoes by plant breeders.

The other daunting challenge is that, once introduced, the pathogen and the disease simply don't go away. "In our experience, growers can expect that once Fusarium wilt gets into their fields, the disease level will never drop to zero. It tends only to increase," says Miyao, who has worked with farmers in Yolo, Sacramento, and Solano counties for 30 years. "And most of the time, it doesn't increase by

Photo courtesy of Flickr/Ric McArthur

a small percent but will double or increase even more dramatically."

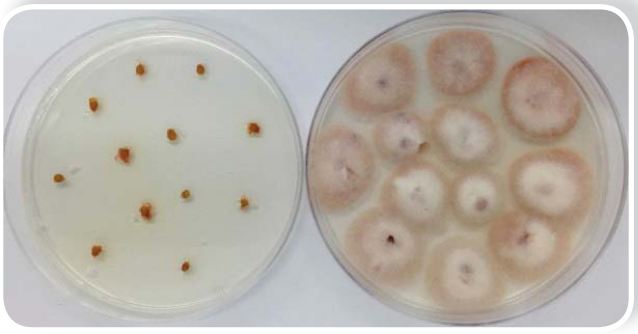
This can be true even when farmers rotate out of tomato for several years. "Reports come in that growers see losses of 10 to 15% in their fields one year, and then they'll grow tomato again three or four years later and have the same losses," Swett says. "So this suggests Fusarium wilt can last in the soil for a long time at the *same* levels."

This means that preventing the disease's further movement is crucial. Growers should always clean vine cutters and harvesters of trailing tomato vines and attached soil before moving their machinery to a new field. This is especially important when the destination is a "clean" field with no Fusarium wilt, Miyao says.

Removing vines and soil does take extra effort, he acknowledges, making the task particularly hard on large-scale producers who harvest tomatoes on thousands of acres in multiple counties. Yet, these large-scale operators are also exactly the ones at highest risk of moving *Fusarium* the fastest and the farthest.

So, "maybe [cleaning] cannot be perfect," Miyao says. "But doing things to reduce the pathogen load before moving to another field just makes sense."

Photo by Edward Sikora, Auburn University, Bugwood.org



Fusarium oxysporum f. sp. *lycopersici* race 3 was recovered from seeds harvested from infected plants in commercial fields. Seeds were plated directly onto selective media for *Fusarium* spp. Photo courtesy of Hung Doan, UC-Davis.

Avoiding infected seeds

In the meantime, UC-Davis researchers have been investigating another dispersal mechanism for Fusarium wilt race 3: through seed. The pathogen is readily isolated from the outside of seed, says Hung Doan, a UC-Davis doctoral student, who has been working on the project with plant pathology professors Mike Davis (now emeritus) and Tom Gordon. The researchers also suspect it can get inside seeds. Doan is currently studying this with funding from the California Tomato Research Institute (CTRI).

Perhaps most troubling, the team has detected race 3 in commercial seed lots. The numbers in this last case are "super-low," Doan says: Only one in about 10,000 to 20,000 seeds carries the pathogen. Still, a single infected seed may be all that's needed for Fusarium wilt to get established—again making containment critical.

On this front, Doan urges all growers to plant only "clean" seed. His experiments show that treating seed with the industry standard, hydrochloric acid, cuts the incidence of infected tomato seeds in commercial fields from about 17% to 0.12%. He's also helping to develop a new fungicide seed treatment.

His other recommendation is crop rotation. "Fusarium wilt is never going to go away," Doan says, "but if you keep planting susceptible plants, the inoculum level could get so high it could lead to the evolution of race 4."

Rotating to a less lucrative crop can be tough, however. "Ideally for disease management, tomato should only be grown every three to four years," Gordon says. "But from an economic standpoint, it can be very difficult for growers to do that."

Then there are the experiences of Miyao and others with Fusarium wilt's longevity. Even after growing a semi-permanent crop, such as alfalfa, for up to four years,

growers have seen Fusarium wilt come roaring back the moment they plant a susceptible tomato variety again, Miyao says.

With support from CTRI, Swett and Doan are now investigating one possible reason for this persistence: the pathogen's ability to colonize resistant tomato cultivars, other crop plants, and even weeds, without causing disease. If Fusarium wilt of tomato is surviving inside these "cryptic hosts," this may allow it to build up in fields even when susceptible tomato varieties aren't grown. Swett is hoping to identify for farmers the best rotation crops to use and those to avoid.

"We all agree that we need to rotate out of susceptible tomato," she says. "But there's this uncertainty: Are all rotation crops created equal in terms of their ability to reduce the levels of Fusarium wilt?"

Echoing Doan's comments, she adds that choosing less risky rotation crops could also help lessen the buildup of *Fusarium* populations overall. "The pathogen's buildup matters a lot for preventing a new race of Fusarium wilt of tomato," she says. "When pathogen populations are smaller, you have less chance of another race emerging, just by chance. But when populations are big, that unlikely chance of having a new race gets more likely."

In the meantime, water use practices in California are changing. Growers are facing the twin challenges of needing to restrict their water use overall *and* rely more on groundwater supplies, which are often more saline than surface waters. Reduced soil moisture and higher soil salinity are a prime recipe for greater plant stress and susceptibility to disease. So, with additional funding from CTRI, Swett is studying how these conditions may affect the severity of Fusarium wilt in a range of race 3-susceptible to race 3-resistant tomato varieties.

"Agricultural producers consistently report that one of their biggest concerns about changing their water use practices is the effect of this on soil-borne pathogens. It's sort of this creeping fear," Swett says. "I think demystifying these risks can really help producers make smart decisions about water use as well as cultivar selection."

Miyao agrees the new research should be useful to farmers, especially if the findings come with management tools. But as people wait for the data, he hopes they won't forget the actions they can take now to fight Fusarium wilt. He especially encourages growers to continue cleaning their equipment. "We need to be vigilant, in a practical sense, when we can," he says. &