The battle for spinach: Tiny crop, huge value, no virgin soil, big trouble

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Spores on spinach roots reveal *Fusarium* fungus infection. The fungus invades the plant's vascular system, feeding on the plant and stealing its water and nutrients. Credit: Washington State University

In the Pacific Northwest, spinach seed is a tiny crop with huge value. And it's in big trouble.

Northwest farmers grow the seeds that fuel the fast-growing baby leaf spinach market. But they're increasingly burdened by a devastating disease that takes their fields out of commission for decades at a time.

Lindsey du Toit aims to change that. A professor at Washington State University, du Toit leads research to help growers reduce the impact of a crippling fungal disease called Fusarium wilt.

A deadly wilt

Thanks to mild, dry summers and long summer days, western Washington and Oregon is the only U.S. region with a suitable climate for spinach seed production.

"No other part of the country has the right conditions," says du Toit.

Only about four thousand acres of spinach seed are farmed here per year, but with seed bringing more than $2,000 per acre, "it's a hugely valuable crop," she said.

A fungus called *Fusarium oxysporum* thrives in the Northwest's acid soils. A strain that only infects spinach arrived here with the first spinach crops more than 80 years ago.

Its spores come to life when spinach roots start growing in the spring. The pathogen grows into the spinach plant's vascular system, or xylem, feeding on the plant itself and stealing the water and nutrients it needs to survive.

"It's like shoving something in your throat while you're trying to

breathe," says du Toit.

As the season warms, the plant has to work harder to feed itself. The disease, *Fusarium* wilt, gets its name from the wilted, worn-out appearance of the plant during summer. Strong plants take longer to succumb, but the fungus often wins, leaving farmers with a reduced seed yield at best. At worst, there's nothing but dead spinach plants—a total loss.

Decades-long wait

To escape the fungus, farmers historically sought out fields where spinach had never been planted. That's a rare opportunity today.

WSU Plant Pathologist Lindsey du Toit, center, with graduate student Shannon Carmody, left, and Kathy Lindbloom, a Sakata Seed America representative, discuss results of soil testing for risk of Fusarium wilt . Credit: Kim Binczewski

"The virgin spinach ground is gone," says Kirby Johnson, president of the Puget Sound Seed Growers Association and a seed farmer for more than 40 years.

Since the fungus is next to impossible to eradicate, farmers have to avoid planting the crop it feeds on. It can take a decade or more for spores in the soil to decline to a level safe for new plantings.

Johnson has waited 17 years and counting for some of his fields to test as safe. But even when they do, farmers still suffer losses.

"Some fields are just a total wipeout," Johnson said.

An added challenge comes from the tight cross-pollination controls that seed farmers must follow. Pollen from unrelated varieties can ruin seed crops. To breed true, spinach fields must be kept apart up to five miles. Limited acreage is planned and mapped every year at a meeting of growers to ensure crops are isolated.

With demand for seed ever increasing, "we have a conundrum on our hands," said Skagit County grower Todd Johnson. Northwest farmers are simply running out of land.

Fingerprints of resistance

How do you stop such a powerful pathogen? For researchers like du

Toit, the key could be resistance: spinach plants with strong natural defenses against *Fusarium*.

She leads Northwest research into *Fusarium* wilt resistance as part of a $266,000 project funded by the U.S. Department of Agriculture's Specialty Crop Research Initiative (USDA award number is 2017-51181-26830). This work is part of a larger, $2 million project led by scientists at the University of Arkansas.

At WSU's Mount Vernon Northwestern Washington Research and Extension Center, du Toit is testing more than 600 varieties of spinach, both long-established local varieties and spinach from around the world, including ancient wild strains from spinach's lands of origin in Iran, Turkey and Syria.

She is hunting for genetic markers—bits of DNA that reveal the varieties that naturally resist Fusarium wilt. To find them, she and her team of students and researchers will grow thousands of plants over the next several years, expose them to the fungus, and study the survivors' DNA. Once they discover the vital genetic fingerprints, spinach breeders could use them to develop fungus-fighting spinach.

Leading WSU spinach research for more than 17 years, du Toit has made important progress. Now, she is convinced that growers need a new tool against Fusarium.

"This is an opportunity to make a huge difference for growers trying to meet the demand for spinach," she said. "By finding resistance and developing an understanding of the genetic mechanisms of resistance, we'll contribute to a healthier Northwest and global spinach industry. That's a win for our farmers and anyone who loves spinach."

Provided by Washington State University