Resolute scientific work could eliminate wheat disease within 40 years

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Wheat and barley growers know the devastating effects of Fusarium head blight, or scab. The widespread fungal disease contaminates grain with toxins that cause illness in livestock and humans, and can render

worthless an entire harvest. As Fusarium epidemics began to worsen across the eastern U.S. in the 1990s and beyond, fewer and fewer farmers were willing to risk planting wheat.

But the battle to eliminate Fusarium head blight never went away. Public breeding programs, with support from the USDA-supported Wheat and Barley Scab Initiative, have been doggedly tweaking soft red winter wheat lines in hopes of achieving greater resistance to the disease.

In a new analysis, University of Illinois researchers say those efforts have paid off. Over the past 20 years, critical resistance metrics have improved significantly. And, they say, if breeding efforts continue, vulnerability to Fusarium head blight could be eliminated within 40 years.

"I don't think anybody realizes it's possible we could eliminate Fusarium head blight as a problem. Forty years sounds like a long time, but by the time I'm retired, the threat of disease could be gone. That would make a huge difference," says Jessica Rutkoski, assistant professor in the Department of Crop Sciences at Illinois and co-author on the new paper.

Rutkoski and her colleagues examined 20 years of data from nine university breeding programs spanning 40 locations in the eastern U.S. That's a whopping 1,068 wheat genotypes.

In each year and each location, researchers inoculated wheat plants with Fusarium spores. They evaluated both test entries (novel wheat lines) and check cultivars (standard across all locations and years) for various resistance traits. The long-term check cultivars act as a kind of barometer, accounting for agronomic practices and environmental factors.

The researchers looked at disease incidence, severity, Fusarium-

damaged kernels, and deoxynivalenol (also known as Vomitoxin) content—the main toxin of concern in Fusarium-contaminated grain. And over 20 years and 1,068 lines, all the resistance traits improved.

"The genetic gain in disease resistance was significant for each of those four traits. Most importantly, we saw a 0.11 parts-per-million decrease in deoxynivalenol per year. Just to see any significant favorable trend is really good," Rutkoski says. "It basically shows that everyone's making progress, and that the investment in public breeding programs is paying off."

Rutkoski says breeders have thrown nearly every technique at wheat to try to improve resistance to Fusarium head blight. It's a tough nut to crack because resistance is controlled by multiple interacting genes.

"It's quantitative resistance. There isn't just one gene that's going to solve it. On the breeding side, people have looked at exotic sources of resistance, such as Chinese lines that have high resistance. Then they'll map the genes and introgress them," Rutkoski says. "That's been successful to some degree, but those genes tend to be associated with unfavorable traits, like lower yield. So, there have been issues."

When Rutkoski analyzed the impact of germplasm introductions from Chinese wheat lines, they weren't responsible for boosting resistance. In other words, progress over the past 20 years was mostly due to breeders exploiting native resistance—the locally adapted wheat's inherent genetic capacity to resist disease—rather than introducing resistance from exotic sources.

That's not to say novel genetic sources of resistance don't have their place. Rutkoski notes it's important to try to identify major-effect genes because often they can help breeders achieve their goals faster.

Ultimately, Rutkoski hopes her results justify and encourage investments in public breeding programs.

"Nobody really notices the progress that's being made. I think there's some skepticism and suspicion that breeding isn't that important. Or people think we need to focus more on genome editing or finding more exotic sources of resistance," she says. "A lot of public breeding programs are getting shut down, and we risk losing all that progress. So, I was gratified to show that the improvement is very consistent over time. And if you just stick to this kind of strategy, you will have guaranteed results. It's not risky."

The article is published in *Plant Disease*.

More information: Rupesh Gaire et al, Genetic trends in Fusarium head blight resistance due to 20 years of winter wheat breeding and cooperative testing in the Northern US., *Plant Disease* (2021). DOI: 10.1094/PDIS-04-21-0891-SR

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