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REPORTS

WASHINGTON GRAIN COMMISSION



To spray or not to spray fungicides is the question, and there are different philosophies about preventative spraying versus waiting until stripe rust shows up in the field.

A different kind of rust belt

By Scott A. Yates

By the time you read this, Eastern Washington will either be in the midst of one of the worst stripe rust epidemics in years—or not.

By the time you read this, farmers will have either tank mixed a fungicide in with their spring herbicide application—or not.

By the time you read this Xianming Chen, Agricultural Research Service scientist and national rust expert, will either be basking in a glow of vindication for his mathematical-based stripe rust model forecast—or not.

Let's back up. On March 4, Chen reported finding stripe rust in a field near Walla Walla. That's early. In three of the last five years, rust didn't show up around the southeast Washington community until late April. The early appearance of the disease along the state's southern border, combined with a relatively mild winter and an early warm up, has Chen estimating losses on stripe rust-susceptible wheat varieties could run as high as 60 percent without a fungicide spray. That's about how

bad stripe rust was in 2010 when Eastern Washington farmers spent \$27 million on fungicide applications to save an estimated 13.7 million bushels of grain worth nearly \$100 million.

It would not be inappropriate to call the Pacific Northwest (PNW) a stripe rust mecca. The first signs of *Puccinia striiformis*, known as yellow rust in many parts of the world, are usually found in the Willamette Valley of Oregon and Mt. Vernon in western Washington, both cool, moist locations where the disease is known to overwinter.

On the east side of the Cascades, however, rust can be killed out during cold winters, which is probably what happened in at least a portion of Washington during an unusual cold spell in the second week of November 2014. But in a good news/bad news scenario, the frigid temperatures killed a lot of wheat too.

Where the weather didn't get cold enough to kill rust, like around Walla Walla and further south into Oregon, the fungus hunkered down in winter wheat fields.

Although stripe rust likes rain and dew while it's infecting plants, during its winter survival mode, dry weather doesn't faze it. When the weather warms up above freezing, the fungus begins to produce yellow-orange pustules on wheat leaves. These features ultimately break open and release a mass of microscopic spores that can blow into the next field, the next state and perhaps even the next continent.

Chen uses mathematical models based on weather variables correlated with data on yield losses from stripe rust plot research going back more than three decades to come up with his forecasts. His loss estimates are based on susceptible varieties that aren't sprayed.

Like the canary in the coal mine which once alerted miners to toxic gases when it keeled over, Chen's forecast is meant to provide farmers a heads-up to the sort of conditions he believes they'll face through the spring and summer growing season. Of course, what he can't

predict with any accuracy is how much rain will fall or how hot it will be, both variables that impact the virulence and spread of stripe rust. Which means his 60 percent loss number on susceptible varieties could be higher or lower.

"Such forecast values are caused by the unusually early and cold period in the second week of November and the unusually warm weather afterwards during the winter," he said. "Although the cold period was widespread in the PNW, there were big variations in how cold."

In the northern end of wheat production in Eastern Washington, it's likely any reservoir of rust inoculum died, but under the right conditions, it will only take a few weeks for the windborne spores to travel from the south to re-infect the area again. That's why Chen often recommends that farmers in the southern parts of the state begin to check their fields three to four weeks ear-

An old adversary evolves with the times

Stripe rust is not a new disease. It probably occurred long before wheat was grown for food around 10,000 years ago. A scientist first described the disease in Europe in 1777, but there are references to rust epidemics in the Old Testament.

Although the disease is thought to have originated in South Asia, perhaps in an area around the Himalayans, it is now found in more than 60 countries and is reported on every continent except Antarctica. The last continent to join the stripe rust community was Australia. It is thought that a traveler carrying stripe rust on his or her clothes infected the country in 1979. Although the disease stayed in the eastern part of the continent for years, it ultimately found its way to west Australia's wheat belt in 2002.

Depending on how you count, a total of 161 races of stripe rust have been identified in the U.S. since the 1960s. Starting in 2010, using a new set of standards, 84 races have been identified in the U.S. In any particular year, however, the number of races that cause a problem is between 23 and 41.

Different races are not just blowing to and fro in the atmosphere, they are constantly evolving, which means a breeder who has developed a wheat variety that has a race-specific resistance can see it fail spectacularly when either another race blows in or changes to an existing race's genetic structure occur. The 2002 release of the spring wheat Zak was a spectacular example of a new race overcoming resistance, which is why most breeders are now looking at stacking different race-specific genes of seedling resistance in

their new varieties, along with more general High Temperature Adult Plant (HTAP) resistance.

Ten years ago, there were only a handful of resistance genes breeders could use to confer resistance. Today, there are many more, but it takes upwards of 15 to 20 years from the discovery of a novel gene to getting it in farmers' fields. Not only that, but some HTAP resistant genes thought to confer general resistance are actually race specific.

Meanwhile, stripe rust appears to be adapting to a warmer climate. Where scientists once spoke of spore propagation shutting down when temperatures exceeded a daily average of 73 degrees, research now indicates some races have increased aggressiveness in their ability to produce spores at higher temperatures.

This, in turn, has generated rust epidemics in places previously considered unsuitable for the disease, like the Midwest, where several major stripe rust outbreaks have occurred in recent years. Not to mention, overwintering rust reservoirs have been established in Louisiana, Texas and perhaps Arkansas, adding those states to the list of places where the disease may serve as the nursery to more widespread infections when conditions are favorable.

Along with the Northwest, stripe rust has shown up throughout the southcentral region of the U.S. this year, also relatively early compared to the past. What does that mean?

"In general, if stripe rust starts developing before March in the southcentral states, an epidemic will likely occur in the entire Great Plains," Chen said. ■



When it comes to stripe rust expertise, you don't get much better than this trio of experts on hand at last year's Farmington Field Day. From left are Mike Pumphrey, Washington State University spring wheat breeder; Tim Murray, Extension plant pathologist; and Xianming Chen, Agricultural Research Service plant pathologist and international rust expert.

lier in the spring than those in its more northern reaches.

"The amount of rust inoculum is determined by the acreage of susceptible versus resistant varieties, race groups and weather conditions," Chen said, singling out several varieties widely grown around Walla Walla as not having adequate resistance under severe rust conditions. Unfortunately, even planting all resistant varieties wouldn't eliminate the stripe rust reservoir since there are many grass hosts for the disease to survive on.

Like wheat prices, stripe rust also follows cycles. The biggest stripe rust epidemic in the state resulted from widespread planting of the club wheat, Omar, which was bred to resist smuts, not rust, and led to devastating stripe rust epidemics in 1960 and 1961. In 1981, another severe outbreak was caused by favorable weather conditions. Although there were some significant stripe rust outbreaks in the state in the 1990s, disease incidence was generally low because of the resistant cultivars being planted, particularly Madsen, which was released in 1988.

"Another factor that influenced stripe rust during the 1990s was that before 2000, spring wheat was grown on less acreage. As less resistant varieties of spring wheat increased in acreage, there were also increased opportunities for stripe rust fungal survival," Chen said, adding that he hopes recently released spring cultivars with high levels of resistance, like Seahawk, will come to dominate spring acreage.

Mike Pumphrey, spring wheat breeder at Washington State University since 2010, said spring wheat stripe rust epidemics are more dependent upon each year's weather than winter wheat. May and June rains—in fact rains all the way up to the Fourth of July—can create havoc in spring wheat.

"If I'm praying for good (stripe rust) screening for my program, I want

All fungi are not created equal

Smut, which was Eastern Washington's biggest problem from the beginning of farming in the region right up to the 1950s, is also a fungus, but a chemical seed treatment almost completely eliminated it as a problem in the region. Unfortunately, there's little chance of having the same luck with stripe rust.

According to Xianming Chen, smuts and rusts are very different diseases caused by different groups of fungi. The smut fungi infects only once during a crop season, usually before emergence.

Smut fungi are also spread by seed and travel relatively short distances by wind blowing soil during harvest. Because of smut's short infection window, seed treatments have proven to be very effective. Also, each species of smut fungi has a narrow host range.

"In contrast, rusts, especially stripe rust, can infect plants from emergence all the way to just before maturity. And stripe rust has a wide host range. Therefore, it is impossible to eradicate," Chen said.

But there may be hope on the horizon. Not only are wheat breeders in the best position ever for transferring a number of resistant genes into varieties, but Mike Pumphrey, spring wheat breeder at Washington State University, believes that if genetic engineering is ever approved and accepted by consumers "there are very straightforward safe ways to control rust through technology on the horizon."

Specifically, he's talking about the potential to silence stripe rust genes in wheat much the same way scientists bred a papaya to silence a virus gene.

"You silence several of those genes at once, using RNA to shut down the growth of the development of rust, and it can't grow," he said. "Just like a vaccination." ■

What can farmers do?

Tim Murray has been a plant pathologist for more than 30 years. He knows the value of chemicals. But when it comes to stripe rust, he advises farmers to be patient and use resistant varieties. That puts the Washington State University (WSU) Extension pathologist at odds with others who argue a prophylactic application of fungicide with a farmer's herbicide treatment is the best approach, regardless of the variety.

"If you are growing a susceptible variety this year, you will likely benefit from early fungicide application, but if you're growing an intermediate or resistant variety, you may not need to pay for a fungicide application. It may be better to wait and watch," Murray said. "My philosophy is to use fungicides when we need to use them and not just prophylactically without considering the resistance of your variety."

At the same time, Murray knows he's pushing against what has become conventional wisdom in the countryside. Part of the reason is because fungicides serve as cheap insurance. Since it has gone off patent, the cost of the active ingredient in Tilt, propiconazole, has plummeted. A farmer can treat an acre for less than the price of a bushel of wheat.

"It is great insurance in one sense, but farmers are limited in the amount of (Tilt) that can be applied per crop season. If you shoot one of your bullets now, you're not going to have it for later, which could require more expensive treatments," he said.

Xianming Chen, an Agricultural Research Service plant pathologist and internationally recognized rust expert, is advising farmers to apply fungicide with their herbicides, but only if stripe rust can be found in the crop and the variety is moderately susceptible or susceptible (five or above on a nine-point rating scale.)

But Mike Pumphrey, who is a national player on the stripe rust stage as well as WSU's spring wheat breeder, admits that if he was a farmer, he'd be hard pressed not to put down a fungicide at herbicide timing this year. And not just as a preventative.

"Studies of fungicide applications in the absence of stripe rust are not consistent, but you'll often see a yield response even if you can't see pathogen infection," he said.

"Under heavy stripe rust pressure, but with a good fungicide program, I can take a susceptible line that would be 30 bushels an acre and make it 60, but I can't make it 70 or 80 bushels—which the most resistant lines would be with the same fungicide application. Chemicals and resistance can work hand in hand," he said.

In 2010, there was a run on fungicides, and distributors struggled to keep up. Gordon Cockrum, crop protection division manager for The McGregor Company, doesn't anticipate that happening this year. But it's not because stripe rust pressure is less.

"In 2010, corn acres were strong, and farmers were applying fungicides to the crop for plant health," he said, adding that since then, corn acres as well as prices, have decreased.

Given Chen's forecast, what Cockrum called a "warning shot," he believes farmers should seriously consider making an initial fungicide application with their spring herbicide tank mix.

"You want to get the field clean to get that initial protection. Then it becomes a matter of monitoring to check the threshold levels at flag-leaf stage. If it shows up then, farmers have to be aggressive because it can get out of control fast," he said. ■

nothing more than a 65 degree day and rain on the Fourth of July. If I get that, the rust explodes on spring wheat," he said, adding that hot weather doesn't appear to shut down spore propagation for newer races like it used to. "I think water is the biggest factor."

The 2010 spring wheat crop came in at a respectable 52 bushels an acre average across the region, but the yield was achieved by the widespread application of fungicides. Even then, Pumphrey believes the crop lost a tremendous amount of potential due to the year's widespread rust infection.

"Losses for spring wheat were severely underestimated that year," he said. "But growers got a wake-up call from the experience having seen the data from their own farms and elsewhere that they need to be vigilant." In 2011, another bad stripe rust year, spring wheat yields increased to 62 bushels an acre.

The headache for breeders like Pumphrey is that wheat varieties which once had their resistance compromised by a new rust race might wind up being resistant to an older race that returns and dominates a particular year. That may inadvertently wind up benefiting farmers, but it presents a conundrum for the breeder who's left to guess at what he's dealing with.

"It makes breeding hard because breeders are trying to select material that is not going up and down depending on the races in a region. You give me four or five good resistance genes that don't change with the weather and are effective and I'm good," he said.

Only Pumphrey wants the right combination of genes because along with protecting the plant from stripe rust, they may also exert a yield drag. In the developing world where single varieties are used for long stretches of time and money for chemical applications are scarce, that's a feasible approach, but in the Northwest, even a 5 percent yield drag costs a farmer far more than applying fungicide does. ■