1. New approach to breeding for leaf rust resistance in wheat

Traditionally, wheat breeders have been selecting for leaf rust resistance by finding lines with strong resistance to one or more races of leaf rust. The problem has been that other races of leaf rust inevitably come along that can overcome that strong, but narrow source of resistance. If that different race of leaf rust becomes widespread in the Southern Plains, the resistant variety rapidly becomes susceptible to leaf rust.

That has happened to most wheat varieties farmers are familiar with – such as Overley, Jagalene, Jagger, and many more.

We are now taking a different approach, similar to the methods used for 20 years or more by wheat breeders at CIMMYT (International Maize and Wheat Improvement Center in Mexico) to develop leaf rust resistance. This approach involves combining 3 or more minor genes for leaf rust resistance into a durable, effective, non-race-specific, slow-rusting form of resistance.

There are several of these so-called minor genes for leaf rust resistance. Two of the better known to plant pathologists and wheat breeders are “Lr34” and “Lr46.”

We have been crossing a genotype called “Amadina” onto Overley. Amadina has four minor genes for leaf rust resistance. We currently have 11 such crosses in the Kansas Intrastate Nursery tests. If all goes well with these experimental lines, we may have a new variety with durable leaf rust resistance ready for release in 2011.

Within the next year or two, we plan for all of our new crosses in the wheat breeding program in Manhattan to include minor gene resistance to leaf rust. This is a departure from the past. Previously, all of our leaf rust resistance breeding was focused on major gene resistance to specific races of leaf rust.
Minor gene, slow-rusting resistance is characterized by:
* Smaller leaf rust pustules
* Fewer leaf rust pustules
* A longer latent period of time between the time of infection and rust pustule development

Varieties with minor gene resistance will be susceptible to leaf rust in the seedling stage, but have durable, non-race-specific resistance in the adult stage. Varieties with a combination of at least three minor genes for leaf rust resistance will usually not be entirely free of leaf rust pustules if leaf rust is present in the area. But the leaf rust will typically occur late in the season and with only light to moderate severity – causing relatively little, if any, yield loss. The best thing is that this type of resistance is effective against all races of leaf rust, making it durable from year to year. Varieties with minor gene resistance should maintain a good level of leaf rust resistance year after year, without becoming fully susceptible.

The minor genes for leaf rust resistance also carry minor gene resistance for stripe rust (yellow rust). Lr34 is linked with Yr18, and Lr46 is linked with Yr29. As a result, the new varieties developed for minor gene, durable, slow-rusting leaf rust resistance will also have the same type of durable resistance for stripe rust.

If this type of durable leaf rust and stripe rust resistance can be incorporated into most or all of our new wheat varieties, that will give us more resources to focus on other traits in our breeding problem, such as scab resistance, Hessian fly resistance, quality, and others.

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2. Nitrogen immobilization as a cause of yellow wheat

There are a lot of wheat fields with a yellowish cast this fall in central Kansas. The most likely cause is nitrogen (N) deficiency. One of the reasons for N deficiency on wheat in the fall is immobilization, especially in wheat following wheat or wheat following corn, with low rates (less than 25 lbs/acre) of N applied.

Immobilization can occur when there are high levels of plant residue with a wide carbon-to-nitrogen ratio mixed in the upper layer of the soil, or present on the soil surface. These plant residues are an energy source for the organisms commonly found in soils. When plant residues are present, soil microbes actively begin to utilize them as a food source. The soil microbes begin reproducing in response to the increased food supply, and in the process they utilize N present in or on the soil. The microbes incorporate N into proteins, nucleic acids, and other organic N compounds.
This N essentially becomes part of the soil organic biomass, and will remain unavailable to plants until the carbon-to-nitrogen ratio drops to < 20:1. At that point N is no longer limiting and some N will be released as NH$_4^+$ through the process of mineralization. Some of the N is present in more stable organic N compounds, or is converted to more stable compounds, and ultimately becomes a part of soil organic matter.

Since it takes time for the population of microorganisms to build up and decompose the residues, this immobilizing process can cause wheat plants to show N deficiency even if fertilizer N was applied.

The extent of immobilization depends largely on the amount of residue present, the ratio C to N in the residue, and the amount of available mineral N (NH$_4^+$ and NO$_3^-$) present in the soil. When the C:N ratio is 20 or lower, mineralization exceeds immobilization; but when the ratio exceeds 30:1, immobilization exceeds mineralization. Wheat straw and corn stalks both have a C:N ratio of 60-80:1. Immobilization and mineralization are also affected by environmental conditions, such as temperature, soil moisture content, and pH.

The photos below show an example of immobilization and chlorotic wheat in a field this fall from Saline County. In this field, the producer incorporated the residue from last year’s wheat crop about three to four inches deep in the soil. This formed a layer of undecomposed residue that created ideal conditions for N immobilization.

The second photo shows chlorotic wheat in that same field. The symptoms are especially severe in an area of the field where the wheat was double-drilled. Where the plant populations are especially high, the competition for N by roots of the young wheat plants outstrips the supply of available N in the soil, which is limited by immobilization due to the layer of undecomposed residue.

Figure 1. Tom Maxwell, Central Kansas District Extension agent, holds up a sample of soil from a Saline County field that has a shallow layer of undecomposed wheat residue.
Figure 2. The layer of undecomposed wheat residue leads to N immobilization and N deficiency symptoms in the wheat crop this fall. Photos by Jim Shroyer, Kansas State University.

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, or Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader 785-532-0397 jshroyer@ksu.edu