New wheat leaf ruts: Impacts, plant resistance and management

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AT A GLANCE…

- Rust pathogens spread freely and rapidly through the Australasian region. While this is predominantly in a west-to-east direction, recent years have seen two examples of east-to-west transport.
- Monitor for the presence of the green bridge, and if present, make sure it is destroyed at least four weeks before crops are sown, either by heavy grazing or herbicides.
- Warm, moist autumn conditions favour the development of leaf rust.
- Monitor crops of vulnerable varieties for leaf rust in 2016 and send samples for pathotype analysis to the Australian Rust Survey. This service is free to all, and is funded by the grower levy paid to the Grains Research and Development Corporation.
- The identification of rust pathotypes involves greenhouse tests in which seedlings of indicator varieties are infected, and takes about three weeks. These tests are increasingly being supplemented with DNA tests that are much quicker (less than 48 hours). The DNA tests provide useful basic information but are nowhere near powerful enough to identify pathotypes.
- Genetic resistance to rust in cereals delivers significant benefit to Australian grain growers, estimated at $1.1 billion annually with wheat alone, and remains the basis of rust control.
- Minimum disease standards remain important for industry-wide benefit from genetic resistance.

WHEAT RUST PATHOGENS

Australian wheat crops are infected by three different rust pathogens:

- Stem rust (caused by Puccinia graminis f. sp. tritici);
- Stripe rust (caused by Puccinia striiformis f. sp. tritici); and,
- Leaf rust (caused by Puccinia triticina).

The identification of rust pathotypes at the PBI is a free service that is open to anyone who would like to submit a sample for analysis (directions on how to do so are provided on page 10). Following this procedure is vital if the viability of a rust isolate is to be ensured.

The sample will be analysed and the sender will be notified of the results.

The success in establishing the distribution and occurrence of known rust pathotypes – and in detecting new rust pathotypes – depends entirely on the collection and submission of samples.

Pathotype identification involves infecting seedlings of a set of cereal varieties, each carrying a different rust resistance gene, with a field collected sample of rust. The ability or inability of the rust isolate to overcome the resistance gene in each variety allows the pathotype or pathotypes present to be identified. These tests take about three to four weeks to complete, and if a new pathotype is suspected, often a longer time is needed to confirm this. The pathotype identification work at PBI is increasingly being supplemented by DNA profiling, which is comparatively quicker and may only take several days.

But while providing important information and a means by which exotic rust incursions can be recognised rapidly, as yet,
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DNA profiling is nowhere near powerful enough to identify individual pathotypes.

The long-term studies of pathogenic variability of rust pathogens conducted at PBI have clearly established that Australia and New Zealand comprise a single rust epidemiological unit, within which rusts migrate freely and rapidly. This is why a nationally coordinated approach to the genetic control of cereal rusts (ie. the Australian Cereal Rust Control Program) is fundamental to success.

The annual surveys of rust variability carried out at PBI have, and continue to form, the basis of all gene-based rust control efforts. They:

- Monitor the effectiveness of rust resistance genes in commercial cultivars;
- Determine the implications of new rust pathotypes in the rust responses of current cereal cultivars;
- Facilitate the discovery and introduction of new resistance genes into locally adapted germplasm; and,
- Allow pre-emptive resistance breeding.

**Recent changes in the wheat leaf rust pathogen**

A new pathotype of the wheat leaf rust pathogen, *Puccinia triticina*, was detected in a sample of leaf rust collected from a crop of the wheat cultivar SQP Revenue at South Bool Lagoon (South Australia) in mid-August 2014.

The new pathotype – 104-1,3,4,6,7,8,10,12 +Lr37 – was considered to be an exotic incursion based on its unique virulence profile and SSR fingerprint. This pathotype is the twelfth documented incursion of an exotic wheat rust pathogen since Australia-wide cereal rust surveys conducted by University of Sydney staff began in 1922.

Following its initial detection in South Australia, pt. 104-1,3,4,6,7,8,10,12 +Lr37 spread rapidly throughout much of the eastern Australian wheat belt and in late September 2015 it was identified in samples of leaf rusted wheat collected from four separate locations in the northern region of the WA wheat belt.

Pt. 104-1,3,4,6,7,8,10,12 +Lr37 carries virulence for the resistance genes Lr27+Lr31, and the adult plant resistance (APR) gene Lr12, and combines this with virulence for Lr13 and Lr37.

All four resistances occur in Australian wheat varieties, and consequently this pathotype has resulted in increased leaf rust susceptibility in some varieties.

**Pathotype surveys and rust control**

To have maximum impact in disease control, surveys of pathogenic variability in rust pathogens must be closely integrated with the development and management of new wheat cultivars.

Where this has been practiced, surveys have provided both information and pathogen isolates that have underpinned rust control efforts, from gene discovery to post-release management of resistance resources.

Information generated by pathotype surveys has been used to devise breeding strategies, inform selection of the most relevant isolates for use in screening and breeding, define the distribution of virulence and virulence combinations. This allows predictions of the effectiveness/ineffectiveness of resistance genes, and the issue advance warning to growers by identifying new pathotypes that overcome the resistance of cultivars before they reach levels likely to cause significant economic damage.

**Maintaining and improving current levels of rust control**

It has been estimated that 50 per cent of the cost of plant improvement involves breeding to maintain current yield and quality levels to meet the challenges of degrading growing environments and evolving pathotypes of major pathogens – in other words, maintenance breeding.

Resistance breeding, and reducing the current impact of rust diseases, is estimated to have saved the industry in the order of $1 billion annually. A continuation of these savings will only be possible if resistance remains a priority in breeding programs, and if the wheat industry as a whole continues to support genetic approaches to rust control.

**Adult plant resistance and rust management decision making**

Many people in the cereals industry would be familiar with the expression that a variety’s disease resistance has ‘broken down’. This expression can be misleading because it suggests that the variety itself has changed in some way. But the shift in a variety’s response to rust is actually caused by a change in the pathogen that causes the disease.

This is why monitoring rust populations for new pathotypes
is critical to increase our knowledge of how a variety’s resistance stacks up.

The emergence of a new rust pathotype can result in a resistant variety becoming more susceptible to rust. Because this shift is often subtle, describing the change in a variety to a new rust pathotype accurately, can be difficult.

Changes in a variety’s response to new pathotypes are influenced by the nature and number of genes that confer resistance to the disease.

Such resistance genes protect against the disease either at all growth stages, which is called all stage resistance (ASR; also referred to as ‘seedling’ or ‘major’ resistance), or at adult plant growth stages only, which is called adult plant resistance (APR; also referred to as minor gene resistance).

Genes that confer ASR usually provide very high levels of protection against rust, while those conferring APR usually provide moderate levels of protection. A variety may carry one or both gene types, resulting in different effects on resistance levels.

Where a variety only carries an ASR gene – and this is overcome by a new rust pathotype – its resistance rating may change from highly resistant to highly susceptible.

**The boom and bust cycle**

There are many examples of such changes in a variety’s resistance levels – the ‘bust’ part of what is known as the ‘boom and bust cycle’.

One of the first examples of this shift was recorded in the Eureka wheat variety’s resistance to stem rust. Eureka was highly resistant to stem rust when it was released in 1938. But because this variety only has one ASR gene (Sr6) to protect it against stem rust, it became highly susceptible to the disease when this single gene was overcome by a new rust pathotype in 1942.

Similarly, the stripe rust resistance rating of Mace was downgraded from highly resistant to very susceptible because it only has one ASR gene (Yr17), which was overcome by a new pathotype in eastern Australia.

But in other grain growing regions such as Western Australia, Mace remains highly resistant to stripe rust because its single ASR gene has not been overcome.

Adding another dimension of complexity are the many wheat varieties that carry a combination of ASR and APR genes. Having both these genes means a pathotypic change can result in a slight increase in susceptibility that occurs when the ASR gene is overcome by a new pathotype, but the APR gene is still effective in providing ‘back-up’ resistance.

Field testing is the only reliable way to determine the levels of back-up resistance provided by the APR gene.

For example, the full impact of the new wheat leaf rust pt. 104-1,3,4,6,7,8,10,12 +Lr37 will not be known until further field tests are completed this year.

While many years of painstaking genetic research has led to a sound understanding of ASR genes, intensive genetic analyses of APR genes began only about 20 years ago. Consequently, information about the APR genes in Australian wheat varieties is incomplete, and varietal information on rust response has partial information only.

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