

Cereal Rust Report

2016

VOLUME 14 ISSUE 3
1st June



The wheat leaf rust pathogen in Australia- pathogenic variation and pathotype designation

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Pathotypes are variants within a pathogen that differ in their ability to overcome rust resistance genes in plants. The identification of cereal rust pathotypes involves infecting seedlings of a set of varieties, each carrying a different known rust resistance gene, with a field collected sample of rust. The ability or inability of the rust isolate to infect each variety allows the pathotype or pathotypes present to be identified. Many systems exist to designate pathotypes (races, strains) of cereal rust pathogens. This document outlines the system used in Australia for designating pathotypes of the leaf rust pathogen of wheat, *Puccinia triticina* (formerly *P. recondita* f. sp. *tritici*), and provides information on the pathogenicity of pathotypes detected over the past 15 years.

The University of Sydney has conducted annual pathotype surveys for cereal rust pathogens since the early 1920s. These surveys depend on co-operators sending samples of rust for analysis. This service is free to all, and is funded by the grower levy managed by the Grains Research and Development Corporation.

The annual pathotype surveys have and continue to form the basis of all gene based rust control efforts. They monitor the effectiveness of rust resistance genes in commercial varieties; determine the implications of new endemic and exotic rust pathotypes in the rust responses of current cereal varieties; facilitate the discovery and introduction of new resistance genes into locally adapted germplasm; and allow pre-emptive resistance breeding.

The identification of pathotypes involves infecting seedlings of a set of cereal varieties, each carrying a different known rust resistance gene, with a field collected sample of rust. The ability or inability of the rust isolate to infect each variety allows the pathotype or pathotypes present to be identified. Tests to identify pathotypes take about 3 to 4 weeks to complete. If a new pathotype is suspected, more detailed greenhouse tests are needed. These subsequent tests involve subculturing the suspect isolate to ensure purity (3-4 weeks), and tests to compare it with

control pathotypes (2-3 weeks). This process may need to be repeated in order to fully characterise a new pathotype.

It is important to note that the decision to define an isolate as being virulent or avirulent for a specific resistance gene is not always simple, and can require multiple tests coupled with field testing to be definitive. This may sound pedantic but results from seedling assays must correlate with what is seen in farmers' paddocks in order for the rust surveys to be useful in agriculture. The need to repeat tests means that occasionally the designation initially given to a pathotype changes at a later date. Admittedly this can add to confusion, but it is important in ensuring the surveys remain relevant to growers' needs.

The pathotype identification work at the Plant Breeding Institute is increasingly being supplemented by DNA profiling, which is comparatively quicker and may only take several days. However, while providing important information and a means by which exotic rust incursions can be recognised rapidly, as yet, DNA profiling is nowhere near powerful enough to identify individual pathotypes.

Pathotype designation in *P. triticina*

The designation system used for *P. triticina* is similar to that used for *P. graminis* f. sp. *tritici* (see Cereal Rust Report 14 (1)). Two differential sets are used, the first being the International Set, comprising four representative genotypes from the differential set developed by North American workers (see Johnston and Browder (1966) Seventh revision of the international register of physiologic races of *Puccinia recondita* f. sp. *tritici*. Plant Disease Reporter **50**: 756–760). The second set, Australian Supplemental Differential Set, comprises 13 wheat genotypes

(Table 1), and as with stem rust pathotypes, virulence on a given differential is indicated by inclusion of the corresponding number in the pathotype formula. Where partial virulence is detected, the number is enclosed in parentheses (eg pathotype 104-2,3,6,(7) is partially virulent for gene *Lr17a*).

Wheat leaf rust pathotypes identified in Australia since 2000, along with their virulence/ avirulence attributes on the most important resistance genes in Australian wheat cultivars are listed in Table 2.

Table 1. Differential genotypes used to identify pathotypes of the wheat leaf rust pathogen *Puccinia triticina* in Australia

Differential set	Line	Key resistance gene (s)
International set	Tarsa	<i>Lr1</i>
	Webster	<i>Lr2a</i>
	Mediterranean	<i>Lr2a, Lr3a</i>
	Democrat	<i>Lr3a</i>
Australian supplementary differentials	1. Thew	<i>Lr20</i>
	2. Gaza	<i>Lr23</i>
	3. Spica	<i>Lr14a</i>
	4. K1483	<i>Lr15</i>
	5. Klein Titan	<i>Lr16</i>
	6. Gatcher	<i>Lr27+Lr31</i>
	7. Songlen	<i>Lr17a</i>
	8. CS 2A/2M	<i>Lr28</i>
	9. Mildress	<i>Lr26</i>
	10. Egret	<i>Lr13</i>
	11. Exchange	<i>Lr16</i>
	12. Harrier	<i>Lr17b</i>
	13. Agent	<i>Lr24</i>
Additional differential genotypes	Sunlin	<i>Lr37</i>
	Sun6B ^a	<i>Lr1, Lr3a, Lr27+Lr31</i>
	Naparoo ^a	<i>Lr13, Lr24</i>
	Agatha ^a	<i>Lr19</i>
	Norka ^a	<i>Lr1, Lr20</i>
	Mentana ^a	<i>Lr3bg</i>
	Morocco ^a	<i>Lr73</i>
	Thatcher +Lr2c ^a	<i>Lr2c</i>
Thatcher +Lr30 ^a	<i>Lr30</i>	

^a Not used in designating pathotypes. Some of these differentials carry genes that are common in Australian wheat varieties, others carry gene combinations that are useful if a sample comprises more than one pathotype

GENERAL ENQUIRIES

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RUSTED PLANT SAMPLES

can be mailed in paper envelopes;
do not use plastic wrapping or plastic
lined packages. If possible, include the
latitude and longitude of the sample
location.

Direct samples to:

University of Sydney
Australian Rust Survey
Reply Paid 88076
Narellan NSW 2567

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Table 2. Pathotypes of the wheat stem rust pathogen *Puccinia triticina* identified in Australia since 2000 (bold lines separate putative clonal lineages)

Pathotype	Resistance gene																	Distribution ^a	Notes
	Lr1	Lr2a	Lr3a	Lr3ka	Lr13	Lr14a	Lr15	Lr16	Lr17a	Lr17b	Lr20	Lr23	Lr24	Lr26	Lr27+Lr31	Lr28	Lr37		
10-1,2,3,4	V ^b	V	A	A	A	V	V	A	A	V	V	V	A	A	A	A	A	E only	Old pathotype, rare
104-2,3,(6),(7),11	V	A	V	A	A	V	A	V	A	A	A	A	A	A	A	A	A	E only	Last detected 2005
104-2,3,(6),(7),11+GH ^c	V	A	V	A	A	V	A	V	A	A	A	V	A	A	A	A	A	E only	Last detected 2000
104-1,2,3,(6),(7),11	V	A	V	A	A	V	A	V	A	A	V	A	A	A	A	A	A	E & W	Common 2000-2009, now rare
104-1,2,3,(6),(7),11 +GH	V	A	V	A	A	V	A	V	A	A	V	V	A	A	A	A	A	E & W	Rare
104-1,2,3,(6),(7),11 +Lr37	V	A	V	A	A	V	A	V	A	A	V	A	A	A	A	A	V	E & W	Was common, now declining
104-1,2,3,(6),(7),11,12	V	A	V	A	A	V	A	V	A	V	V	A	A	A	A	A	A	E only	Last detected 2004
104-1,2,3,(6),(7),9,11	V	A	V	A	A	V	A	V	A	A	V	A	A	V	A	A	A	E only	Last detected 2007
104-1,2,3,(6),(7),9,11,12	V	A	V	A	A	V	A	V	A	V	V	A	A	V	A	A	A	E only	Rare, detected once only, 2000
104-1,2,3,(6),(7),11,13	V	A	V	A	A	V	A	V	A	A	V	A	V	A	A	A	A	E only	Common 2000-2008, now infrequent
104-1,2,3,5,(6),(7),11 +GH	V	A	V	V	A	V	A	V	A	A	V	V	A	A	A	A	A	W only	Rare, detected once only, 2002
122-1,2,3,(6),(7),11	V	V	V	A	A	V	A	V	A	A	V	A	A	A	A	A	A	E & W	Rare, detected last in 2014
122-1,2,3,(6),(7),11 +GH	V	V	V	A	A	V	A	V	A	A	V	V	A	A	A	A	A	E only	Rare, detected last in 2014
53-1,(6),(7),10,11	A	A	A	A	V	A	A	V	A	A	V	A	A	A	A	A	A	E only	Last detected in 2000
53-1,(6),(7),10,11,12	A	A	A	A	V	A	A	V	A	V	V	A	A	A	A	A	A	E only	Last detected in 2001
53-1,4,(6),(7),10,11,12	A	A	A	A	V	A	V	V	A	V	V	A	A	A	A	A	A	E only	Rare, detected once only, 2001
64-(6),(7),(10),11	V	A	A	A	(V)	A	A	V	A	A	A	A	A	A	A	A	A	E only	Last detected in 2000
76-1,3,5,10,12	A	A	V	V	V	V	A	A	A	V	V	A	A	A	A	A	A	E only	Rare, last detected in 2005
76-1,3,5,9,10,12	A	A	V	V	V	V	A	A	A	V	V	A	A	V	A	A	A	E only	Rare
104-1,3,5,10,12	V	A	V	V	V	V	A	A	A	V	V	A	A	A	A	A	A	E only	Rare, detected once only, 2002
10-1,3,9,10,11,12	V	V	A	A	V	V	A	V	A	V	V	A	A	V	A	A	A	E only	Exotic, detected Vic 2005, now rare
10-1,3,4,9,10,11,12	V	V	A	A	V	V	V	V	A	V	V	A	A	V	A	A	A	E only	Rare, detected since only, 2005
76-3,5,7,9,10 +Lr37	A	A	V	V	V	V	A	A	V	A	A	A	A	V	A	A	V	E only	Exotic, detected Vic 2005
76-3,5,7,9,10,12 +Lr37	A	A	V	V	V	V	A	A	V	V	A	A	A	V	A	A	V	E only	Rare, first detected 2008
76-3,5,7,9,10,12,13 +Lr37	A	A	V	V	V	V	A	A	V	V	A	A	V	V	A	A	V	E only	Common, first detected 2013
76-1,3,5,7,9,10,12 +Lr37	A	A	V	V	V	V	A	A	V	V	V	A	A	V	A	A	V	E & W	Common, first detected 2011
76-1,3,5,7,9,10,12,13 +Lr37	A	A	V	V	V	V	A	A	V	V	V	A	V	V	A	A	V	E only	Common, first detected 2013
104-1,3,5,7,9,10,12 +Lr37	V	A	V	V	V	V	A	A	V	V	V	A	A	V	A	A	V	E only	Rare, first detected 2013

104-3,5,7,9,10,12 +Lr37	V	A	V	V	V	V	A	A	V	V	A	A	A	V	A	A	V	E only	Rare, first detected 2013
104-1,3,4,6,7,8,10,12 +Lr37	V	A	V	A	V	V	V	A	V	V	V	A	A	A	V	V	V	E & W	Exotic, detected SA 2014, now common

^a E = Eastern Australia, W = Western Australia

^b V = virulent (**able** to overcome the resistance gene), A = avirulent (**unable** to overcome the resistance gene)

^c "GH" indicates that the isolate is fully virulent for Lr23 ("Gaza High")