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The wheat stem 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 stem rust pathogen of wheat, *Puccinia graminis* f. sp. *tritici* (*Pgt*), 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 genetic 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, and if a new pathotype is suspected, often a longer time is needed to confirm this.

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 seeding 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. graminis* f. sp. *tritici*

In Australia, pathotypes of *Pgt* are given a pathotype designation on the basis of two differential sets. The first set, The International Set, comprises six genotypes that represent key differentials from the original Stakman set (see Stakman, Stewart and Loegering, (1962) Identification of physiologic races of *Puccinia graminis* f. sp. *tritici*. USDA Research Service E617). The International Set is used to assign a Standard Race designation (eg 98, 343, 34 etc), by using a key included in the publication by Stakman *et al*. (1962). The second set, known as the Australian Supplemental Differential Set, comprises 11 wheat and two triticale genotypes numbered from 1 to 13. Virulence on a given differential is indicated by inclusion of the corresponding number in the pathotype designation. Hence, pathotype 98-1,2,3,5,6 is Standard Race 98 as determined by the International Set, and is virulent on Australian supplemental differentials 1 (*Sr6*), 2 (*Sr11*), 3 (*Sr9b*), 5 (*Sr17*), and 6 (*Sr8a*). Both sets of differentials are listed in **Table 1**.

Wheat stem rust pathotypes identified in Australia since 1990, 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 stem rust pathogen *Puccinia graminis* f. sp. *tritici* in Australia

Differential set	Line	Key resistance gene (s)
International set	Reliance	*Sr5*
	Marquis	*Sr7b*
	Acme	*Sr9g*
	Emmer	*Sr9e*
	Einkorn	*Sr21*
	Line S	*Sr13*
Australian supplementary differentials	1. McMurachy	*Sr6*
	2. Yalta	*Sr11*
	3. W2402	*Sr9b*
	4. W1656	*Sr36*
	5. Renown	*Sr17*
	6. Mentana	*Sr8a*
	7. Norka	*Sr15*
	8. Festiguay	*Sr30*
	9. TAF 2	*SrAgi*
	10. Entrelago de Montijo	*SrEm*
	11. Barleta Benvenuto	*Sr8b*
	12. Coorong	*Sr27*
	13. Satu	*SrSatu*
Additional differential genotypes[a]	SrNin	*SrNin*
	Gatcher	*Sr2,Sr5,Sr6,Sr8a,Sr12*
	Comb X	*Sr5b,7b,9b*
	Kite	*Sr26*
	Agent	*Sr24*
	Norin 40	*SrNorin40*
	Cook	*Sr5,Sr6,Sr8a,Sr36*
	Banks	*Sr5,Sr8a,Sr9b,Sr12*
	Egret	*Sr5, Sr8a, Sr9b, Sr12*
	Mendos	*Sr11,Sr17,Sr36*
	Mildress	*Sr31*
	Mokoan	*Sr9b*
	W3534	*Sr22*
	W3763	*Sr32*
	Sr35	*Sr35*
	Trident	*Sr38*

[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

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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

The Australian Cereal Rust Control Program is supported by growers through the Grains Research & Development Corporation.

Table 2. Pathotypes of the wheat stem rust pathogen *Puccinia graminis* f. sp. *tritici* identified in Australia since 2000

	Resistance gene																	
Pathotype	*Sr5*	*Sr6*	*Sr8a*	*Sr9b*	*Sr9g*	*Sr11*	*Sr15*	*Sr17*	*Sr22*	*Sr24*	*Sr26*	*Sr27*	*SrSatu*	*Sr30*	*Sr31*	*Sr36*	*Sr38*	Notes
21-0	A[a]	A	A	A	V	A	A	A	A	A	A	A	A	A	A	A	A	Rare
34-2	V	A	A	A	V	V	A	A	A	A	A	A	A	A	A	A	A	Last detected in 2003
34-2,7 [Yalta low]	V	A	A	A	V	V	V	A	A	A	A	A	A	A	A	A	A	See footnote (b)
34-2,7	V	A	A	A	V	V	V	A	A	A	A	A	A	A	A	A	A	Last detected in 2009
34-2,7,10	V	A	A	A	V	V	V	A	A	A	A	A	A	A	A	A	A	Last detected in 2003
34-1,2,7	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	A	Last detected in 2010
34-1,2,7,10	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	A	Last detected in 2003
34-1,2,7 +Sr38 [Yalta low]	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	Australian wheat cultivars respond much the same to all of these pathotypes. Pt 34-1,2,7 +Sr38 is common
34-1,2,7 +Sr38	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	
34-1,2,7,10 +Sr38	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	
34-1,2,7 +Sr38 +Norin 40	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	
34-1,2,7 +Sr38 +Sr21	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	
34-1,2,7 +Sr38 +Sr9e	V	V	A	A	V	V	V	A	A	A	A	A	A	A	A	A	V	
34-2,12,13	V	A	A	A	V	V	A	A	A	A	A	V	V	A	A	A	A	Satu triticale pathotype, not in WA
11-2,12,13	V	A	A	A	V	V	A	A	A	A	A	V	V	A	A	A	A	Rare
343-1,2,3,5,6	V	V	V	V	A	V	A	V	A	A	A	A	A	A	A	A	A	Oxley pathotype
34-1,2,3,5,6	V	V	V	V	V	V	A	V	A	A	A	A	A	A	A	A	A	Rare
98-1,2,3,5,6	V	V	V	V	V	V	A	V	A	A	A	A	A	A	A	A	A	Common
98-1,2,3,5,6,7	V	V	V	V	V	V	V	V	A	A	A	A	A	A	A	A	A	Wyalkatchem pathotype
98-1,2,3,5,6,9	V	V	V	V	V	V	A	V	A	A	A	A	A	A	A	A	A	Rare
222-1,2,3,5,6,7	V	V	V	V	A	V	V	V	A	A	A	A	A	A	A	A	A	Rare, last detected in 2008

[a] A = avirulent (**unable** to overcome the resistance gene), V = virulent (**able** to overcome the resistance gene)
[b] "Yalta Low" indicates that the isolate is virulent for *Sr11* in Yalta, but avirulent for an uncharacterised resistance gene in this differential