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

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Issue 1 in this volume of the Cereal Rust Report introduced a working definition of a pathotype; outlined the importance of understanding pathotypes of cereal rusts in managing cereal rust diseases; and described the process for pathotyping. The current issue describes the system used in Australia for designating pathotypes of the stripe rust pathogen of wheat, *Puccinia striiformis* f. sp. *tritici* (*Pst*), and provides information on the pathotypes detected over the past 10 years.

An annual survey of the pathotypes of wheat stripe rust has been conducted at the University of Sydney since *Puccinia striiformis* f. sp. *tritici* (*Pst*) was first detected in the country in 1979. For the majority of that time, the pathotyping has been done by staff from the NSW Department of Primary Industries. The survey is funded by the grower levy via the Grains Research and Development Corporation, and facilitated by The University of Sydney, Plant Breeding Institute.

Pathotype designation in *P. striiformis* f. sp. *tritici*

Several differential sets exist around the globe to pathotype *Pst*. The Australian method uses a modified version of the European system developed in 1972 and modified in 1990 (see Wellings & McIntosh (1990) *Puccinia striiformis* f. sp. *tritici* in Australia: pathogenic changes during the first 10 years. *Plant Pathology* 39:316-325). It uses an International Set, a European Set and a set of Australian supplementary differentials (**Table 1**). The International Set is comprised of nine differentials, while the European Set has eight differentials and there are 12 differentials in the Australian supplementary set.

The International and European sets use a decanery system to allocate pathotype number. In a decanery system each of the individual lines used in the differential set is allocated a unique value on a power of two scale: 2^0=1, 2^1=2, 2^2=4, 2^3=8 etc. as shown in **Table 1**. If a differential line is susceptible to the isolate being tested (*i.e.* the isolate is deemed virulent for the gene/s present in that differential line), it is given the corresponding decanery value. Once scoring a differential set is completed, all the decanery values allocated to the isolate are added together to provide the unique pathotype number. To separate the International and European set results, the European number is given the prefix 'E'.

The Australian supplementary set includes nine wheat and two triticale genotypes that are either cross checks to virulences in the International and European sets (*Yr2*, *Yr9*, *Yr25*), to differentiate virulent pathotypes that occur in Australia but are not differentiated by the International or European sets (*Yr17*, *Yr27*, *YrT*, *YrJ*) or to screen for potential virulences not yet reported in Australia (*Yr15*, *Yr33*). Susceptible reactions on the supplementary differentials are indicated in the pathotype name with a '+' sign after the gene name, e.g.: the value 17+ after the pathotype number indicates that the isolate is virulent on *Yr17*. Whether the isolate is virulent or avirulent on the Avocet resistance (*YrA*), composed of the complementary resistance genes *Yr73* and *Yr74*, is indicated by A+ or A-, respectively, in the pathotype name.

The nomenclature for the main pathotypes of *Pst* in Australia since 1979 is provided in **Table 2**. As an example of how the naming system works in practice, consider pathotype 134 E16 A+ 17+, the current dominant pathotype across the eastern wheat belt. From Table 2, the decanery values for this pathotype are 2, 4, 128 (2+4+128 = 134) and E16. It is also virulent on Avocet R, the Australian supplementary differential for the *YrA* resistance, and the *Yr17* supplementary differentials. When using the decanery values to decode a pathotype name to determine the differentials that are susceptible to the isolate, it is important to start by subtracting the largest possible differential decanery value first. Using the example above, 128 is the largest power of two that can be subtracted from 134: 134-128 = 6, 6-4 = 2 and 2-2 = 0 so the decanery values for this isolate are 2, 4 and 128.

The virulence/ avirulence attributes of wheat stripe rust pathotypes identified in Australia since 2005 for the most important resistance genes in Australian wheat cultivars are listed in **Table 3**.

Table 1. Differential genotypes used to identify pathotypes of the wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici* in Australia

Differential set	Line	Key resistance gene(s)	Decanery value
International set	Chinese 166	*Yr1*	2^0= 1
	Lee	*Yr7*	2^1= 2
	Heines Kolben	*Yr2*, *Yr6*	2^2= 4
	Vilmorin 23	*Yr3*	2^3= 8
	Moro	*Yr10*	2^4= 16
	Strubes Dickkopf		2^5= 32
	Suwon 92/Omar		2^6= 64
	Clement	*Yr2*, *Yr9*	2^7= 128
	Triticum spelta var. *album*	*Yr5*	2^8= 256
European set	Hybrid 46	*Yr4*	2^0= E1
	Reichersberg 42	*Yr7*	2^1= E2
	Heines Peko	*Yr2*, *Yr6*	2^2= E4
	Nord Deprez		2^3= E8
	Compair	*Yr8*	2^4= E16
	Carstens V	*Yr32*	2^5= E32
	Spaldings Prolific		2^6= E64
	Heines VII	*Yr2*, *Yr25*	2^7= E128
Differential set	**Line**	**Key resistance gene(s)**	**Supplementary value**
Australian supplementary set	Avocet R	*YrA* (*Yr73*, *Yr74*)	A+/A-
	Kalyansona	*Yr2*	
	Trident	*Yr17*	17+
	Ellison	*Yr17*	17+
	Yr15/6* AvS NIL	*Yr15*	
	Hugenoot	*Yr25*	
	Selkirk	*Yr27*	27+
	Yr9 AvS NIL	*Yr9*	
	EGA Gregory	*Yr33*	
	Tobruk	*YrT*	T+
	Breakwell	*YrJ*	J+

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

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

Table 2. Nomenclature of pathotypes of the wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici* identified in Australia since 2005.

		International set									**European set**								**Australian supplementary differentials**				
		Chinese 166 (*Yr1*)	Lee (*Yr7*)	Heines Kolben (*Yr2, Yr6*)	Vilmorin 23 (*Yr3*)	Moro (*Yr10*)	Strubes Dickkopf	Suwon 92/Omar	Clement (*Yr2, Yr9*)	*Triticum spelta* album (*Yr5*)	Hybrid 46 (*Yr4*)	Reichersgerg 42 (*Yr7*)	Heines Peko (*Yr2, Yr6*)	Nord Desprez	Compair (*Yr8*)	Carstens V	Spaldings prolific	Heines VII (*Yr2*)	Avocet	*Yr17*	*Yr27*	Jackie	Toburk
Pathotype	Decanery:	1	2	4	8	16	32	64	128	256	E1	E2	E4	E8	E16	E32	E64	E128	A+/-	17+	27+	J+	T+
64 E0 A-								64											A-				
64 E1 A-								64			E1								A-				
104 E137 A-					8		32	64			E1			E8				E128	A-				
104 E137 A+					8		32	64			E1			E8				E128	A+				
104 E137 A- 17+					8		32	64			E1			E8				E128	A-	17			
104 E153 A-					8		32	64			E1			E8	E16			E128	A-				
106 E139 A+			2		8		32	64			E1	E2		E8				E128	A+				
110 E143 A+			2	4	8		32	64			E1	E2	E4	E8				E128	A+				
238 E143 A+			2	4	8		32	64	128		E1	E2	E4	E8				E128	A+				
134 E16 A+			2	4					128						E16				A+				
134 E16 A+ 17+			2	4					128						E16				A+	17			
134 E16 A+ 17+ 27+			2	4					128						E16				A+	17	27		
134 E16 A+ J+			2	4					128						E16				A+			J	
134 E16 A+ J+ 27+			2	4					128						E16				A+		27	J	
134 E16 A+ J+ T+			2	4					128						E16				A+			J	T
150 E16 A+			2	4		16			128						E16				A+				

Table 3. The virulence and avirulence of pathotypes of the wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici* identified in Australia since 2005

	Resistance Gene [a]																		
Pathotype	*Yr1*	*Yr2*	*Yr3*	*Yr4*	*Yr5*	*Yr6*	*Yr7*	*Yr8*	*Yr9*	*Yr10*	*Yr15*	*Yr17*	*Yr25*	*Yr27*	*Yr32*	*Yr33*	*YrA*	*YrJ*	YrT	Year last detected
64 E0 A-	A	V	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	2015 (rare)
64 E1 A-	A	V	A	V	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	2014 (rare)
104 E137 A-	A	V	V	V	A	A	A	A	A	A	A	A	V	A	A	A	A	A	A	2009
104 E137 A- 17+	A	V	V	V	A	A	A	A	A	A	A	V	V	A	A	A	A	A	A	2007
104 E137 A+	A	V	V	V	A	A	A	A	A	A	A	A	V	A	A	A	V	A	A	2008
104 E153 A-	A	V	V	V	A	A	A	V	A	A	A	A	V	A	A	A	A	A	A	2008
106 E139 A+	A	V	V	V	A	A	V	A	A	A	A	A	V	A	A	A	V	A	A	2005
110 E143 A+	A	V	V	V	A	V	V	A	A	A	A	A	V	A	A	A	V	A	A	2015 (rare)
134 E16 A+	A	V	A	A	A	V	V	V	V	A	A	A	V	A	A	A	V	A	A	2015
134 E16 A+ 17+	A	V	A	A	A	V	V	V	V	A	A	V	V	A	A	A	V	A	A	2015
134 E16 A+ 17+ 27+	A	V	A	A	A	V	V	V	V	A	A	V	V	V	A	A	V	A	A	2015
134 E16 A+ J+	A	V	A	A	A	V	V	V	V	A	A	A	V	A	A	A	V	V	A	2015
134 E16 A+ J+ 27+	A	V	A	A	A	V	V	V	V	A	A	A	V	V	A	A	V	V	A	2013 (rare)
134 E16 A+ J+ T+	A	V	A	A	A	V	V	V	V	A	A	A	V	A	A	A	V	V	V	2014 (rare)
150 E16 A+	A	V	A	A	A	V	V	V	V	V	A	A	V	A	A	A	V	A	A	2005 (only detected once)
238 E143 A+	A	V	V	V	A	V	V	A	V	A	A	A	V	A	A	A	V	A	A	2005

[a] A = avirulent (**unable** to overcome the resistance gene), V = virulent (**capable** of overcoming the resistance gene)