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Plant Breeding Institute

Confirmation of the exotic origins of two pathotypes of the wheat stripe rust pathogen detected in 2017 and 2018, and their impact

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Wheat stripe rust was first detected in Australia in 1979. Pathology testing at that time implicated Europe as the source of the stripe rust isolate, and inadvertent human mediated transport as the means of entry. A second stripe rust incursion was detected in 2002, into WA. In this case the presumed origin of the new “WA” pathotype group was North America. The origins of these two incursions have since been verified using DNA-based tests. Here, we document two further exotic incursions of wheat stripe rust, the first detected in 2017 and reported on by us in May 2018 (Cereal Rust Report **Volume 16 Issue 1**; pathotype 239 E237 A- 17+ 33+), and the second detected initially in August 2018 for which we reported preliminary information on earlier this year (Cereal Rust Report **Volume 17 Issue 1**; pathotype 198 E16 A+ J+ T+ 17+). An update is provided on the origins of these two new pathotypes and their impacts in agriculture. Should climatic conditions over summer be favourable for cereal and grass growth, growers are advised to monitor for potential green bridge development and rust survival. Samples of all rusts observed in cereal crops or on volunteer cereals and grass weeds should be submitted for pathotype analysis to the Australian Cereal Rust Survey, details are provided at the end of this document.

Wheat stripe rust pathotype 239 E237 A- 17+ 33+

This pathotype was first detected in samples of stripe rust infected wheat collected from Normanville and Horsham in Victoria in November 2017. Although it was not detected in 2018 and only a single isolate was identified in 2019 (from Victoria), 15 isolates were recovered in the 2020 season from widespread locations throughout NSW. The distribution of this pathotype and others can be viewed using our web-based interactive map at <https://www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/cereal-rust-research/rust-reports.html>.

Genome wide SNP marker-based genotyping of this pathotype and representatives of other Australian wheat stripe rust isolates showed clearly that pathotype “239” was genetically distinct from all other known endemic Australian wheat stripe rust isolates. Working with colleagues at the Global Rust Reference Centre at Aarhus University Denmark, we were able to place this pathotype into Multi-locus Genotype (MLG) PstS10. This is the most common MLG of the wheat stripe rust pathogen in Europe at present (**Figure 1**), strongly implicating this region as the origin of this pathotype. Three pathotypic variants of this pathotype have been identified in Europe to date, based on their abilities to attack the wheat cultivars Warrior, Kalmar and Benchmark. The resistance genes in these cultivars are unknown, but our work suggests that at least one carries *Yr33*. We are currently investigating this further.

The latest responses of Australian wheat cultivars to this pathotype based on detailed greenhouse and field testing were provided in the last Cereal Rust Report (**Volume 17 Issue 3**). Updated refined responses will be provided in early 2021 based on results from the National Variety Trials 2020 cycle.

Wheat stripe rust pathotype 198 E16 A+ J+ T+ 17+

This pathotype was first detected near Wagga Wagga in late August 2018, and was subsequently isolated from Victoria and Tasmania that year. In 2019, it was once again isolated from these states and also from Queensland and was in fact the most common pathotype of the wheat stripe rust pathogen isolated from eastern Australia in that year. In 2020 it was once again the dominant stripe rust pathotype in eastern Australia (67% of all isolates), being isolated from all mainland eastern states.

Our initial work in characterizing the pathogenicity of this pathotype showed that it resembled an existing endemic

pathotype, viz. 134 E16 A+ J+ T+ but differed in two attributes (viz. virulence for the stripe rust differential resistances *YrSuwon92/Omar* and *Yr17*). It is highly unusual to find new rust pathotypes in Australia that differ from an existing one in more than one virulence/avirulence, and for this reason we undertook detailed genetic and pathogenic analyses of the new 198 pathotype.

Our detailed greenhouse testing combined with field observations and whole genome sequencing clearly established that this pathotype is genetically distinct from the 134 family of stripe rust pathotypes, and that it represents a fourth incursion of the wheat stripe rust pathogen into Australia.

Once again, in collaboration with our colleagues at the Global Rust Reference Centre in Denmark we were able to place this pathotype into the MLG PstS13. This MLG is also common in Europe at present (**Figure 1**) where it is principally associated with triticale. It has caused total crop failure in organically grown triticale and was responsible for severe stripe rust epidemics on durum and bread wheat in Italy in 2017. Significantly, this MLG was introduced into South America in or before 2016, where it caused severe stripe rust epidemics on over 3 million hectares of wheat in Argentina in the 2016/17 and 2017/18 cropping seasons. Many growers there applied fungicides but were unable to control the disease and suffered significant economic losses. Yield losses of between 53 and 70% were recorded in the seven most susceptible varieties being grown.

Only a single pathotype has been detected within this PstS13 lineage, strongly implicating either Europe or South America as the origin of this incursion.

Work at the Plant Breeding Institute has shown that significantly, pathotype 198 E16 A+ J+ T+ 17+ differs from the 134 group of pathotypes in its ability to infect some Australian cultivars of common wheat, durum wheat, barley and triticale. Some of these differences have important implications for the grains industry.

Common wheat

Unlike pathotypes within the “134” group, pathotype 198 E16 A+J+ T+ 17+ is avirulent for a resistance gene in the wheat stripe rust differentials Clement, Heines VII, Heines Peko, Reichersberg 42, Spaldings Prolific, and Hugenoet, which is likely *Yr25* (**Figure 2**). Detailed comparative tests have shown the likely occurrence of

the same resistance gene in the Australian wheat cultivars Cosmick, Derrimut, DS Pascal, Hydra, LRPB Flanker, LRPB Spitfire, Sunprime, and Wallup (**Figure 3**). The same gene likely occurs in the older wheats Halberd, Janz, Oxley, Cook, Condor and WW15. It is possible that at least in some cases the complementary resistance genes *Yr73+74* ("*YrA*") may account for the resistance observed in some of these genotypes. If this is verified, the designation of this pathotype will change.

These results show that most fortunately some of the wheat cultivars currently grown in Australia are more resistant to the 198 pathotype than they are to the older "134" group pathotypes. These results also account for associations between specific wheat cultivars and either the "134" group of pathotypes or pathotype 198 E16 A+ J+ T+ 17+ that have emerged in processing stripe rust samples submitted for pathotype analysis in 2020. We are continuing genetic analyses to confirm the specific rust resistance gene(s) involved.

Data collected from the field during 2019 by NSW DPI, AgVic and the University of Sydney indicated that pathotype "198" poses an increased threat to several wheat varieties (e.g. DS Bennett and LPB Trojan and to a lesser extent Devil, Illabo, DS Darwin, Emu Rock and Hatchet CL Plus). The latest responses of Australian wheat cultivars to this pathotype based on detailed greenhouse and field testing was provided in the last Cereal Rust Report (**Volume 17 Issue 3**). Updated refined responses will be provided in early 2021 based on results from the National Variety Trials 2020 cycle.

Durum wheat

As reported in Cereal Rust Update **Volume 17 Issue 2**, several durum varieties (e.g. DBA Artemis, DBA Bindaroi, DBA Lillaroi, DBA Spes, DBA Vittaroi and EGA Bellaroi) are more susceptible to pathotype 198 E16 A+ J+ T+ 17+ (**Figure 4**). While our initial tests implicated the resistance of the wheat stripe rust differential Suwon92/Omar in this, further testing suggests that pathotype 198 E16 A+ J+ T+ 17+ likely overcomes an as yet uncharacterized seedling resistance gene in these durum wheat cultivars. Further genetic studies are underway to characterize the resistance that has been rendered ineffective in these durums by the 198 pathotype.

The latest responses of Australian durum wheat cultivars to this pathotype based on detailed greenhouse and field testing were provided in the last Cereal Rust Report (**Volume 17 Issue 3**). Updated refined responses will be provided in early 2021 based on results from the National Variety Trials 2020 cycle.

Barley

Detailed greenhouse tests have established that pathotype 198 E16 A+ J+ T+ 17+ differs from the "134" group of pathotypes in being virulent for one or more major (seedling) genes conferring stripe rust resistance in barley. Cultivars that carry the resistance overcome by pathotype "198" include: Brindabella, Clipper, Ketch, Maritime, Prior, RGT Planet, Shepherd, and Tantangara (**Figures 1 and 5**). Despite this, we found no evidence of pathotype 198 E16 A+ J+ T+ 17+ on barley crops in eastern Australia in 2020, so it would appear that all current barley cultivars have very good levels of resistance to this pathotype and that it poses no threat at this stage to the barley industry.

Several samples of stripe rust from barley crops were received in 2020; all were immediately genotyped using diagnostic SSR markers upon receipt and pathogenicity tested in the greenhouse, and all proved to be the Barley Grass Stripe Rust (BGR) pathogen. There is circumstantial evidence that the BGR pathogen may now have increased virulence on barley grass, and that its more common occurrence in barley crops in 2020 is a function of increased inoculum load. We are conducting tests at present to examine this.

Triticale

One of the intriguing features of evolution in the wheat stripe rust pathogen in eastern Australia over the past 18 years or so has been the acquisition of virulence for several resistance genes in triticale. Pathotypes within the "134" group have virulence for three stripe rust resistance genes that occur in triticale, all of which are on the rye genome: *Yr9*, *YrJackie*, *YrTobruk*. While virulence for *Yr9* existed in the pathotype that entered Australia in 2002 (i.e. pathotype 134 E16 A+), local mutations gave rise to virulence for *YrJackie* (first detected in 2007) and *YrTobruk* (first detected in 2010). This adaptation to triticale was a significant contributing factor in the damaging stripe rust epidemics experienced in eastern Australia from 2008 through 2011 as it allowed very early epidemic onset due to stripe rust build up in early sown triticale crops and later movement into main season wheat crops.

Coincidentally, pathotype 198 E16 A+ J+ T+ 17+ is also virulent for these three resistance genes in triticale. Detailed seedling tests in our greenhouse system have, however, indicated that this pathotype is also virulent for a fourth resistance in triticale, which is carried by the cultivars Astute, Berkshire, Bison, and Joey. The latest responses of Australian triticale cultivars to this pathotype based on detailed greenhouse and field testing were provided in the last Cereal Rust Report (**Volume 17 Issue 3**). Updated refined responses will be provided in early 2021 based on results from the National Variety Trials

2020 cycle.

Concluding comments

The confirmation of two further incursions of the wheat stripe rust pathogen brings to four the number documented since this disease was first detected in Australia in 1979. The evidence available implicates Europe as the source of three of these incursions (1979, 2017 and 2018) and North America as the source of the other one (2002). This continues the trend that has emerged from our long-term pathogenicity surveys of cereal rusts of an increasing frequency of exotic incursions with time, presumably associated with increased international movement of people and inadvertent transport of rust spores on contaminated clothing.

Stripe rust was very common in wheat crops in eastern Australia during the 2020 season, and there were many situations in which fungicides were used to control the disease. This was principally due to the occurrence of pathotype 198 E16 A+ J+ T+ 17+. The amount of stripe rust that developed was, however, nowhere near that caused

by the same pathotype in Argentina in 2016/17 and 2017/18. The value of existing stripe rust resistance in Australian wheat cultivars in minimizing yield losses due to this pathotype in particular is even more apparent when one considers just how favourable the 2020 cropping season was for stripe rust. The much lower impact of 198 in Australia compared to its impact in Argentina and Europe is a clear endorsement of the value of genetic resistance in controlling rust diseases in cereals, and of the efforts of all stakeholders in using genetics as the foundation of rust control here in Australia.

Should climatic conditions over summer be favourable for cereal and grass growth, growers are advised to monitor for potential green bridge development and rust survival. Samples of all rusts observed in cereal crops or on volunteer (self-sown) cereals or grass weeds should be submitted for pathotype analysis to the Australian Cereal Rust Survey, see below for details.

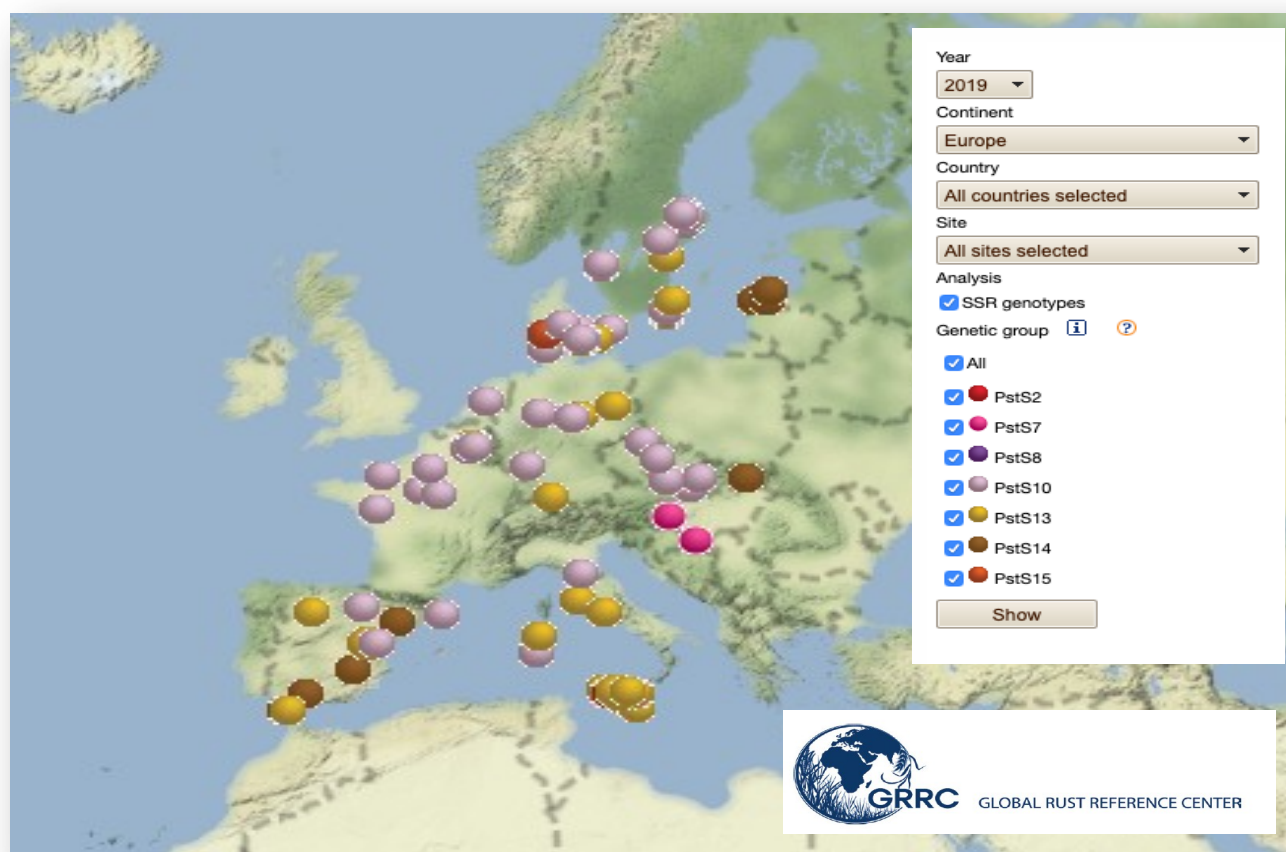


Figure 1: Distribution of isolates of the wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici* in western Europe in 2019, based on microsatellite genotype (“Molecular Lineage Group”). Note the widespread occurrence of MLGs PstS10 and PstS13, to which pathotypes 239 E237 A- 17+ 33+ and 198 E16 A+ J+ T+ 17+ belong, respectively.

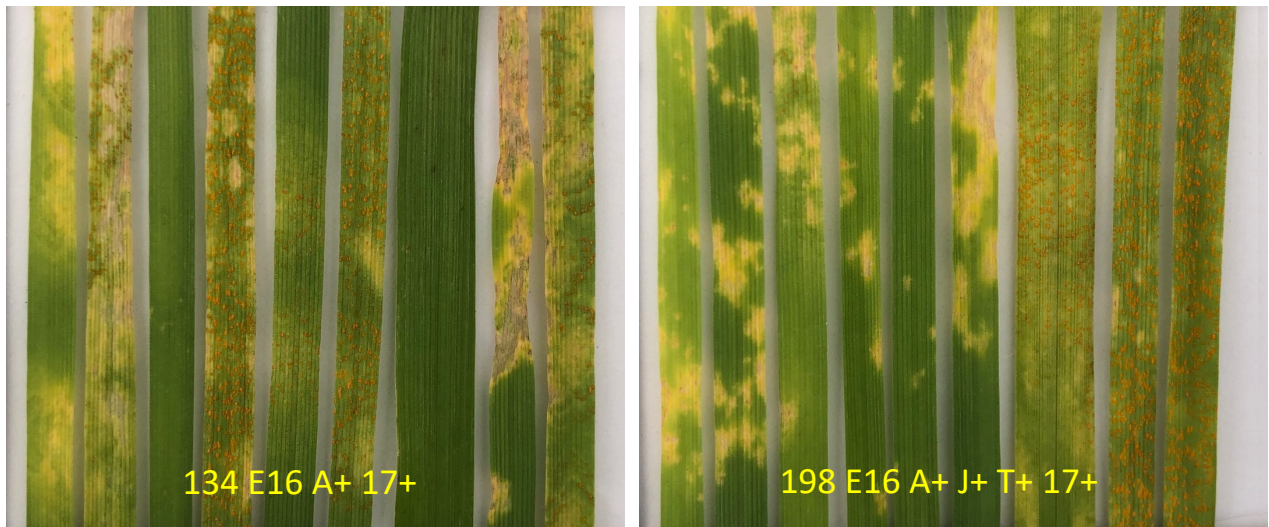


Figure 2: The responses of primary leaves of nine cereal differential genotypes used for identifying pathotypes of the wheat stripe rust pathogen (*Left to right*: Clement, Rechesberg 42, Spaldings Prolific, Heines Peko, Heines VII, Hugenoet, Maritime barley, Tobruk triticale (Yr7), Breakwell triticale (YrJ)) infected with two different pathotypes of the wheat stripe rust pathogen. Pathotype 198 E16 A+ J+ T+ 17+ (right) is avirulent for a resistance gene in the first six wheat genotypes to which pathotype 134 E16 A+ 17+ (left) is virulent, likely Yr25.

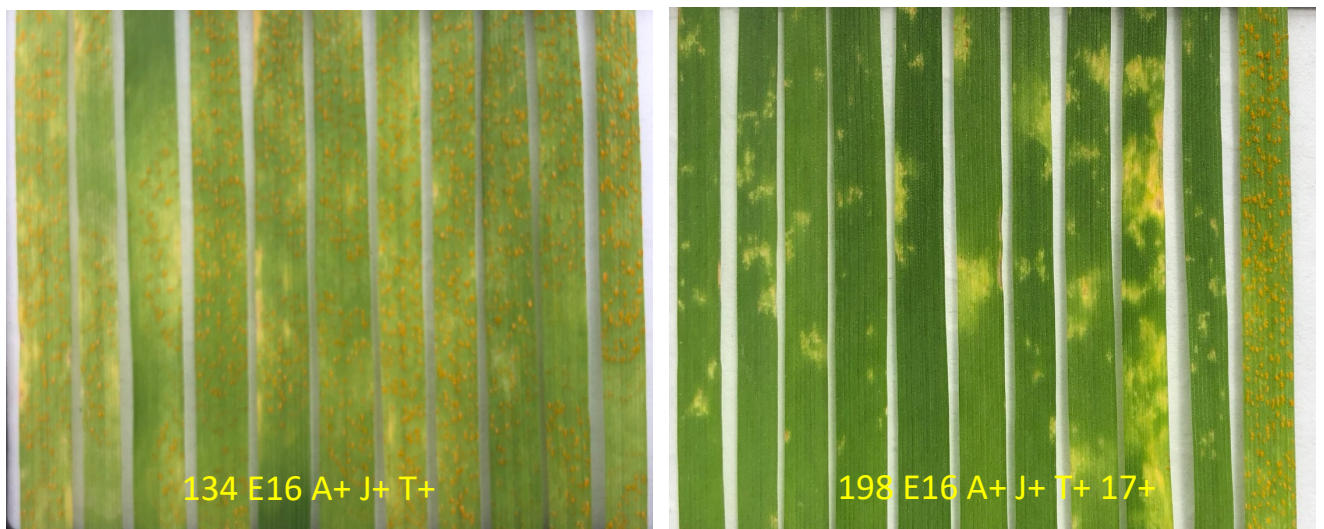


Figure 3: The responses of primary leaves of 11 wheats (*Left to right*: Cosmick, Derrimut, DS Pascal, Hydra, LRPB Spitfire, Wallup, Janz, Oxley, Condor, WW15, Morocco) infected with two different pathotypes of the wheat stripe rust pathogen. Pathotype 198 E16 A+ J+ T+ 17+ (right) is avirulent for a resistance gene to which pathotype 134 E16 A+ J+ T+ (left) is virulent, likely Yr25.

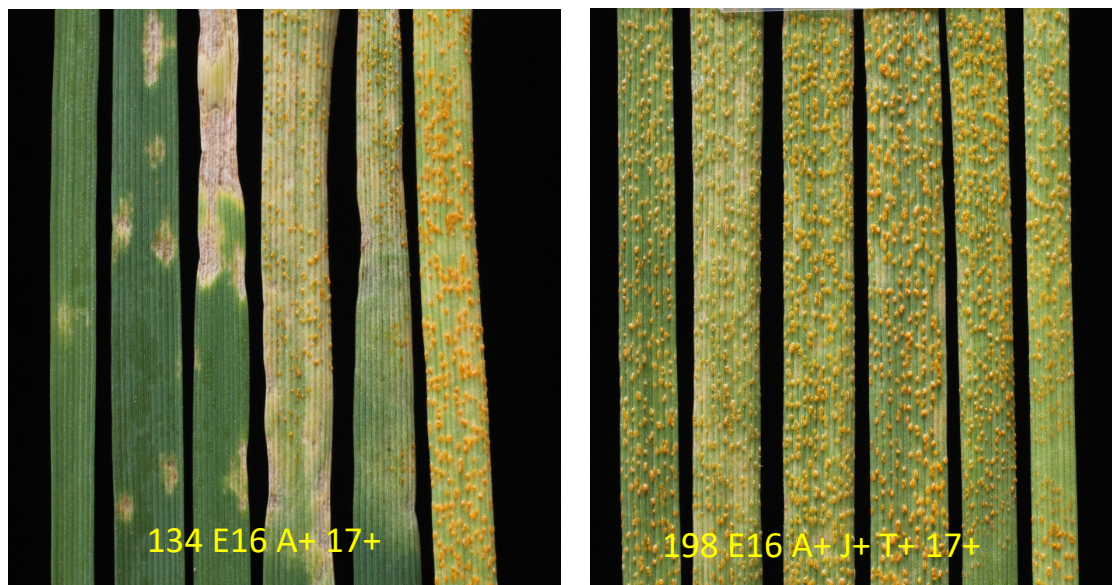


Figure 4: The responses of primary leaves of four durum wheats and two common wheats (*Left to right*: Suwon92/Omar, DBA Bindaroi, DBA Vittaroi, DBA Lillaroi, Gundaroi, Avocet S) infected with two different pathotypes of the wheat stripe rust pathogen. Pathotype 198 E16 A+ J+ T+ 17+ (right) is virulent for a resistance gene in these cultivars to which pathotype 134 E16 A+ 17+ (left) is avirulent.

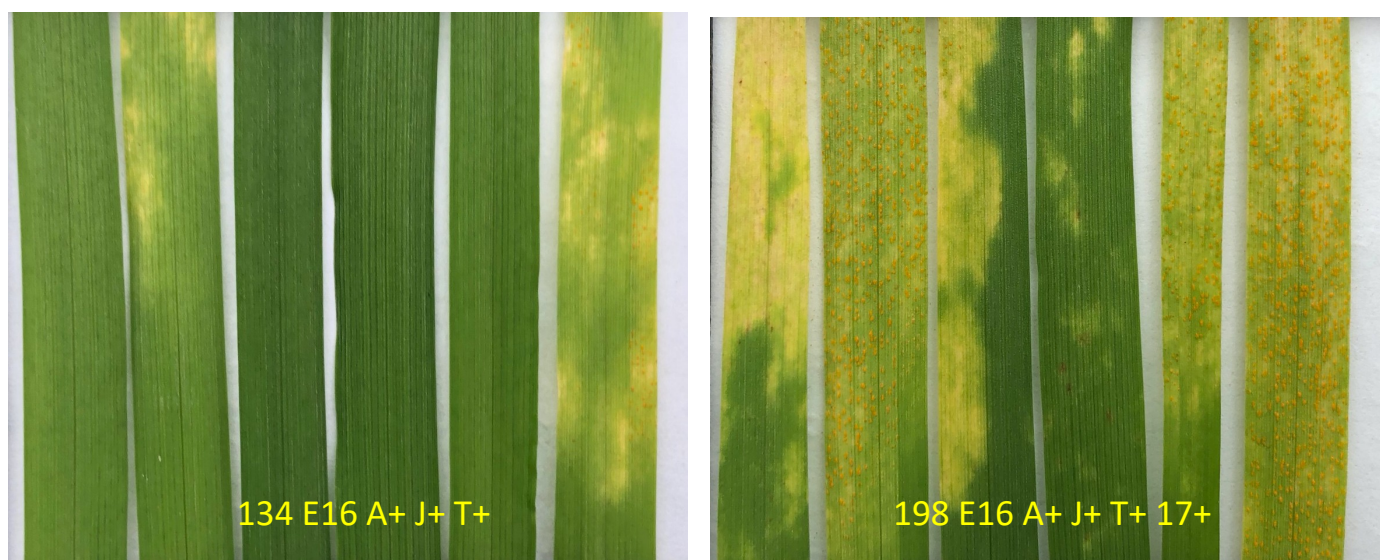


Figure 5: The responses of primary leaves of six barleys (*Left to right*: Ketch, Maritime, Prior, Shepherd, Topper, Sudan) infected with two different pathotypes of the wheat stripe rust pathogen. Pathotype 198 E16 A+ J+ T+ 17+ (right) is virulent for a resistance gene in these cultivars to which pathotype 134 E16 A+ 17+ (left) is avirulent.

The success of our rust surveys depends entirely on the samples received for analysis- hence as always, growers and other stakeholders are encouraged to monitor crops, self-sown cereals, and key grass species that harbour the cereal rust pathogen, closely for rust, and to forward freshly collected samples **in paper only** to the Australian Cereal Rust Survey, at University of Sydney, Australian Rust Survey, Reply Paid 88076, Narellan NSW 2567.

*****We cannot stress enough how important it is not to post samples in plastic of any kind
– rust fungi do not like this!*****

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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,
date of collection, cultivar, and your full
contact details.

Direct rust samples to:

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

The Australian Cereal Rust Control Program is
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