Information note: stem rust/black rust of wheat: Ug99 - a new virulent strain

Stem rust or black rust of wheat is caused by the fungal pathogen, *Puccinia graminis* f.sp. *tritici*. The host range of this form of *P. graminis* is inconsistently reported in the literature but it is fairly wide (up to 28 species[7]) with its main asexual host being wheat (*Triticum spp.*); other cereals and a range of grasses can also become infected. The fungus completes its sexual cycle on the broad-leaved hosts barberry (*Berberis* spp.) and *Mahonia*. Its distribution is worldwide. The potential for new races to evolve through sexual reproduction, or to overwinter on the broad-leaved hosts in cooler areas where *P. graminis* cannot survive on wheat, has been dealt with in the past by barberry eradication programmes.[3]

Stem rust needs green plant tissue to be able to infect. It is favoured by hot days (25 to 30ºC), mild nights (15 to 20ºC) and frequent dews. The urediniospores, which are the asexual infective spores for cereal and grass hosts, are spread long-distances by wind and deposited by rain.[9] They can also be moved as contaminants on human clothing.[8]

Historically, stem rust has caused massive yield losses of wheat wherever it occurred, but in recent years it has been effectively controlled through selection and breeding for stem rust resistance genes known as *Sr* genes.

There are at least 50 *Sr* genes which confer resistance to different races of stem rust. Globally, the pathogen has virulence for many of these genes and so they cannot be deployed in wheat breeding programmes. For example; virulence has been detected to *Sr13* in Ethiopia in durum wheat areas; to *Sr24* in South Africa and India; and, to *Sr27* in Australia and South Africa.

Significantly, in 1999, virulence to *Sr31* was detected in Uganda; this race has virulence to a number of other *Sr* genes and is known as Ug99 (or TTKS).[4] *Sr31* was derived from Petkus rye and has been used extensively as the main source of resistance to stem rust in breeding programmes for many wheat cultivars. In 2006, stem rust monitoring in Kenya detected isolates of Ug99 which had virulence to *Sr24*. This gene was described as previously being effective against most races of stem rust worldwide.[5]

By overcoming the main sources of host resistance in the varieties of wheat that are commonly grown in Africa and Asia, Ug99 has spread from Uganda to Kenya, Ethiopia, Sudan, Yemen and Iran. It is now surmised that it may also be in Pakistan. It has been disseminated long-distance by wind, with the early (unanticipated) spread to Asia purported to be due to Cyclone Gonu in early June 2007.[2] Ug99 is highly damaging to wheat production and is reported to have caused yield losses of up to 71% in experiments.[4]

Claire Sansford, CSL, May 9th, 2008

Breeding for multigene resistance to Ug99 will take at least five years. It involves crossing disease-resistant lines with wheat varieties adapted to local conditions in the world's wheat-growing countries. Seed multiplication then follows to produce sufficient planting material for areas at risk from Ug99.[2]

CIMMYT and ICARDA have started a 'Global Rust Initiative' to address this problem. This includes a programme to screen wheat from around the world for resistance genes and development of chemical strategies for short-term control.[4] Fungicides can reduce the level of stem rust but would not eradicate the pathogen and would be expensive, even if available in developing countries. Population monitoring by means of 'trap nurseries' and sampling and analysis of the races of *P. graminis* in areas of Africa are also in place.

Some institutes have their own initiatives. For example, in the UK, John Innes and the University of Free State, South Africa are collaborating on a 4-year project to investigate 300 African wheat varieties for resistance to stem rust.[1]

There is a potential risk of spread to Europe if Ug99 spreads to northern Africa. However, it would have to arrive before the wheat crop had fully matured in order to be able to infect, and the temperature and moisture requirements are such that the weather in northern Europe would have to be exceptional at heading, for infection, disease and crop losses to occur.

Crop monitoring in the UK, including that undertaken by NIAB (the UK Cereal Pathogen Virulence Survey) should detect the pathogen. However, should the pathogen arrive and the climate become favourable for establishment, if UK wheat cultivars are susceptible, the long-term strategy for control would be breeding for resistance, which needs to be done in advance and must be durable.

REFERENCES

1. Anon. (2008a). BBSRC/DFID Sustainable Agriculture for International Development. Media Briefing , February 2008. http://www.bbsrc.ac.uk/media/briefings/080221_sarid.pdf

2. Anon. (2008). Wheat crops at risk – killer fungus spells disaster. RedOrbitNews. 12 March 2008. http://www.redorbit.com/news/science/1293009/wheat_crops_at_risk__killer_fungus_spells_disaster/index.html?source=r_science

3. APS (1977). Compendium of Wheat Diseases. The American Phytopathological Society. 106pp.

4. CIMMYT (2005). Sounding the Alarm on Global Stem Rust. An Assessment of Ug99 in Kenya and Ethiopia and Potential for Impact in neighbouring Regions and Beyond. 29 May 2005. 26pp.

5. Jin Y, Pretorius ZA, Singh RP (2007). New virulence within race TTKS (Ug99) of the stem rust pathogen and effective resistance genes. *Phytopathology*, **97**, S137.

6. Jin Y, Singh RP (2006). Resistance in US wheat to recent Eastern African isolates of *Puccinia graminis* f. sp. *tritici* with virulence to resistance gene *Sr31*. Plant Disease, **90**, 476-480.

7. Leonard KJ, Szabo LJ (2005). Pathogen profile. Stem rust of small grains and grasses caused by *Puccinia graminis*. *Molecular Plant Pathology*, **6**, 99-111.

8. Singh RP, Hodson DP, Jin Y, Huerta-Espin J, Kinyua MG, wanyera R, Njau P, Ward RW (2006). Current status, likely migration and strategies to mitigate the threat to wheat

production from race Ug99 (TTKS) of stem rust pathogen. CAB Reviews: perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources. **1**, 054.

9. USDA (2008). Wheat stem rust. http://www.ars.usda.gov/Main/docs.htm?docid=9910