Current status of wheat stem rust race Ug99 in South Africa

Symptom of stem rust on the stem of wheat. The main sign is the development of dark-red, elliptical pustules (masses of spores) mainly on the stem, and sometimes on the leaf and head of wheat. Photo by ZA Pretorius.

Stem rust (black rust) is an important disease of bread wheat in South Africa. It is frequently found in the winter rainfall wheat growing regions of the Western Cape, sometimes reaching epidemic levels and causing significant economic loss. Susceptible cultivars could suffer more than 35% yield loss. The main sign of stem rust is the development of dark-red, elliptical pustules (masses of spores) mainly on the stem, and sometimes on the leaf and head of wheat.

Dr Tarekegn Terefe
ARC-SMALL GRAIN, BETHLEHEM

ALTHOUGH RESISTANT CULTIVARS provide effective stem rust control, the fungus that causes stem rust frequently acquires new virulence to overcome the resistance in existing cultivars. The appearance, adaptation and spread of the stem rust race Ug99 (TTKSK) highlights the importance of stem rust variability in global wheat production.

Ug99 is a highly virulent race which was detected in Uganda, East Africa in 1999. Ug99 overcame the resistance gene *Sr31* which had been effective and widely used in resistance breeding for more than three decades. During the last 20 years, variants of Ug99 have emerged overcoming additional resistance genes such as *Sr24*, *Sr36* and *SrTmp*. In addition, Ug99 and its variants had spread to several countries. To date, thirteen Ug99 variants are known and one or more of these races have been confirmed in thirteen countries, including South Africa (**Table 1**).

To mitigate the negative impact of the stem rust pathogen which continually evolves, researchers in many wheat producing countries conduct rust monitoring (surveillance). Monitoring of the stem rust population helps to timeously detect and control new races, preventing potential outbreak and economic loss.

New races detected through surveys can also be used in screening and identification of effective resistance, thereby ensuring continual availability of resistant cultivars to wheat growers. Therefore, the national rust monitoring programme at ARC-Small Grain (ARC-SG) has been conducting annual surveys which made significant contributions to sustainable control of stem rust in SA. Through such surveys, conducted over the past two decades, five of the thirteen Ug99 variants have been confirmed in SA. These include 2SA88 (TTKSF, North American race notation), 2SA106 (TTKSP), 2SA107 (PTKST), 2SA88+ (TTKSF+) and 2SA42 (PTKSK).

Race TTKSF (virulent on resistance genes *Sr9e* and *Sr38*) was first detected in SA in 2000 and has dominated the stem rust population over the last 20 years. This race is similar to TTKSP, except for its avirulence on *Sr24*. The widespread occurrence of TTKSF can be mainly attributed to its virulence on several resistance genes and the cultivation of susceptible wheat cultivars in the Western Cape, where stem rust regularly occurs. In addition to its broader virulence, TTKSF probably possesses other fitness traits which may have contributed to its predominance over the past several years.

Race TTKSP (virulent on *Sr24*, *Sr38*) was first identified in 2007 in the Western Cape and has not been detected outside the province. Given its broader virulence than TTKSF, race TTKSP was expected to predominate. However, the population of TTKSP gradually declined and disappeared as this race has not been detected since 2011. The poor establishment of TTKSP compared to races with relatively lower virulence suggests that it probably lacked other fitness traits associated with virulence.

Race PTKST (virulent on *Sr24*, *31*, *38*) was first detected in 2009 in KwaZulu-Natal. It was also found in 2010 in the Free State. However, it has not been detected in the subsequent seasons except in 2014 and 2017 when it was found in a few samples collected in Bethlehem, Free State. The infrequent occurrence of PTKST could be due to the absence of favourable weather for infection and dissemination, particularly in KwaZulu-Natal and the Free State, where it was previously detected. So far, PTKST has not been detected in the Western Cape.

The fourth race, TTKSF+, was detected in the Free State in 2010. This race is similar in its virulence profile to TTKSF except for its virulence on the South African winter wheat cultivar

TO PAGE 16

Current status of wheat stem rust race Ug99 in South Africa

FROM PAGE 15

Matlabas (*Sr9h*). Since its initial detection in 2010, TTKSF+ has been found only in 2013 in a few samples collected in Tygerhoek and Moorreesberg in the Western Cape.

More recently, a few isolates which were collected from wheat near Bethlehem in the Free State in 2017 were identified as a new Ug99 variant race 2SA42 (PTKSK) (virulent on *31* and *38*). This brought the number of Ug99 variants detected in SA to five. Except for avirulence on *Sr24,* PTKSK is similar to the existing race PTKST. In the subsequent years, PTKSK was found in samples collected in a few localities in the Free State, confirming its establishment and potential to cause infection in the years to come.

New races commonly arise through genetic mutation occurring in locally existing races. They can also be transported over long distances and enter new areas through their wind-borne spores or by sticking to clothes and shoes of travellers. Genetic studies on the Ug99 variants and existing stem rust races in SA showed low similarity between TTKSF, PTKST and the existing races. Therefore, it is unlikely that these Ug99 variants developed locally from existing races through a step-wise mutation. These two races should rather be considered exotic introductions.

Similar genetic studies suggested that TTKSP might not represent an introduction but rather a local adaptation. Races TTKSF, TTKSF+ and PTKST have been reported in other African countries, including Zimbabwe and Mozambique (Table 1), suggesting that these countries, especially those close to South Africa, could be the sources of some of the races found in SA. Presently, it is not known if PTKSK arose locally from PTKST or represents a new introduction into SA. This race has been reported in Ethiopia, Kenya and Yemen.

From the relatively older Ug99 variants in SA, PTKST was found to be more virulent as several South African spring wheat cultivars and breeding lines were susceptible to it. However, PTKST has still not been observed in the Western Cape, where spring wheat is widely cultivated and the weather is conducive for stem rust development.

Table 1. Ug99 (TTKSK) and its variants confirmed in South Africa and other countries. Adapted from RustTracker (https://rusttracker.cimmyt.org/).

No.	Country	Virulence on key stem rust resistance genes	Ug99 variants#
1	Egypt	*Sr24, Sr31, Sr38, SrTmp*	TTKST, TTKSK, TTKTK
2	Eritrea	*Sr24, Sr31, Sr38, SrTmp*	TTKSK, TTKST, PTKST, TTKTK
3	Ethiopia	*Sr24, Sr31, Sr36, Sr38*	TTKSK, TTTSK, PTKST, PTKSK
4	Kenya	*Sr24, Sr31, Sr36, Sr38, SrTmp*	TTKSK, TTKST, TTTSK, PTKSK, PTKST, TTKTT, TTKTK, TTHSK, PTKTK, TTHST
5	Mozambique	*Sr24, Sr31, Sr38*	PTKST
6	Rwanda	*Sr24, Sr31, Sr36, Sr38, SrTmp*	TTKSK, TTKST, TTTSK, TTKTK
7	South Africa	*Sr24, Sr31, Sr38, Sr9h*	TTKSF, TTKSF+, TTKSP, PTKST, PTKSK
8	Sudan	*Sr31, Sr38*	TTKSK
9	Tanzania	*Sr24, Sr31, Sr36, Sr38*	TTKSK, TTTSK, TTKST
10	Uganda	*Sr24, Sr31, Sr36, Sr38, SrTmp*	TTKSK, TTTSK, TTKST, TTKSF, TTKTK
11	Zimbabwe	*Sr24, Sr31, Sr38, Sr9h*	TTKSF, TTKSF+, PTKST
12	Iran	Sr31, Sr38	TTKSK
13	Yemen	Sr31, Sr38	TTKSK, PTKSK

#The 13 Ug99 variants known so far are underlined

Furthermore, different resistance genes that are effective against PTKST were identified and some of these have been incorporated into breeding lines by ARC-SG, as described below. The recently detected race PTKSK is less virulent on SA wheat cultivars compared to PTKST. Hence, it should not pose a significant threat to local wheat production.

To mitigate the challenges of rapid resistance breakdown due to the emergence of new races, researchers from ARC-SG together with national and international collaborators have been continually screening wheat germplasm to identify resistance sources which are effective against Ug99 variants and other stem races known in SA and other countries. The identified resistance genes have been and will continue to be incorporated into breeding material to develop cultivars with a broad spectrum of resistance.

Efforts are in progress at ARC-SG to improve durability of stem rust resistance through pyramiding of two or more major genes in combination with minor genes conferring adult plant resistance. Pyramiding of these genes is being supported by the use of diagnostic DNA markers. These efforts will contribute to the development of cultivars with multiple resistance and increased durability.

Conclusion

From the thirteen Ug99 variants known worldwide so far, five have been confirmed in SA. Some of these races are most likely foreign introductions into this country, emphasising the continued vulnerability of the South African wheat industry to new stem rust races that could emerge locally or through migration from other countries.

In an effort to reduce the negative impacts of Ug99 variants and other new stem rust races, ARC-SG has been regularly conducting rust surveys to timeously detect new races and screen available resistance sources. This has assisted in the identification and utilisation of several resistance genes which are effective against Ug99 variants present in and outside SA.

The ongoing rust surveys should be strengthened and continued in order to reduce the negative impacts of Ug99 variants and other virulent stem rust races that could be detected in SA in the future.