Stem rust – threat to global wheat production

Dr Tarekegn Terefe, ARC-Small Grain Institute

Stem rust, also called black rust, is a devastating fungal disease of wheat in many countries. Severely infected plants may not produce any seed or only a few and shrivelled kernels. Therefore, the disease can result in a total yield loss on highly susceptible cultivars under favourable weather conditions.

Moisture is necessary for stem rust infection and temperatures of 20 - 25 °C favour optimum development of the disease. In South Africa, stem rust regularly occurs in the mild winter wheat growing regions of the Western Cape, sometimes causing significant epidemics.

Stem rust appears as elongated pustules consisting of dark red powdery masses of spores (urediniospores) mainly on the stem and leaves of infected wheat. When the disease pressure is high, individual pustules could conjoin and cover an entire wheat stem, making it appear red-brown in colour. Such severely infected stems could easily break or yield low numbers of undesirable grains. When the plants approach maturity, the colour of the pustules turns black.

Several cycles (generations) of urediniospores may occur in one season. A single pustule of stem rust can produce hundreds of thousands of spores, each of which has the potential to cause a new infection.

Historically, stem rust has caused severe epidemics in different countries and remains a major problem in many wheat-growing regions across the globe. In 1999, the then new stem rust race, Ug99, was discovered in Uganda (Ug stands for Uganda and 99 for the year in which the race was first identified). Ug99 defeated the resistance gene Sr31, which had been effective for more than 40 years, rendering 90% of wheat cultivars grown worldwide vulnerable to the stem rust infection.
This highly virulent race is considered a serious threat to food security worldwide, particularly in Africa and Asia. To mitigate the potential threat, the Borlaug Global Rust Initiative (BGRI), a community of wheat and rust researchers, was established in 2005 to coordinate global research aimed at controlling Ug99 and other rust races. Some resistant lines, which could replace susceptible cultivars in countries under high risk, have been identified through this concerted global effort.

**Stem rust management**

Resistant cultivars: Growing resistant cultivars is the most cost-effective means of controlling stem rust. However, one major obstacle to sustainable use of genetic resistance is the frequent appearance of new stem rust races that are able to overcome different resistance genes. New races develop mostly through mutation of local races and/or through the introduction thereof from other countries, which then can cause severe epidemics on previously resistant cultivars. Spores of such new races can be carried by wind over long distances, between countries or even continents. They can also be transported over long distances by attaching to travellers’ clothing. Human-assisted rust transport continues to be a challenge with the increasing global movement of people.

Most commonly, however, stem rust spreads over short distances, for example, within a country or region. The spread within Africa and to Asia of Ug99 appears to have occurred in a stepwise fashion during the past 15 years. To date, Ug99-related races have been confirmed in over ten African and two Asian countries. It is clear that a new aggressive race observed in a specific location will not be limited to the locality where it was first observed. Four of the eight Ug99 variants reported so far have been confirmed in South Africa, and there is evidence to suggest that some of these, and other races, probably entered South Africa from neighbouring countries.

Stem rust will continue to evolve into new races that have the potential to spread between different countries, emphasising the importance of a strong rust monitoring system in South Africa. Rust monitoring is an effective strategy to reduce the negative impacts of continually evolving stem rust pathogens on resistant cultivars. It helps to timely detect and control new races, thereby preventing possible disease outbreaks and damage to wheat. Races detected through surveys can be used in resistance breeding programmes. As a result, rust monitoring or surveillance has been a major component of the wheat-breeding programme at ARC-Small Grain Institute (ARC-SGI) over the past three decades. From these surveys, more than 30 stem rust races have been discovered and used in screening breeding material to enable continual development of new resistant cultivars.

In an effort to proactively identify wheat lines that are resistant to stem rust races not yet in South Africa, researchers from the ARC-SGI have, annually, been screening wheat germplasm at the international stem rust screening nursery in Kenya in collaboration with BGRI. Promising lines have been identified and are being used in breeding programmes. In this way, the ARC-SGI has been making a significant contribution to profitable wheat production in South Africa, mainly by developing moderately resistant to resistant cultivars to wheat rusts. Recommended cultivars are evaluated annually to see if their resistance is still effective and these results are reported every year in the Small Grain Production Guideline, published by the national cultivar evaluation team of the ARC-SGI. The booklet also provides information about other wheat diseases.

**Chemical control:** Fungicides provide better protection when resistant cultivars are not available or when resistance in existing cultivars becomes ineffective due to the emergence of new virulent stem rust races. It should be noted that excessive use of fungicides could have severe side effects on the environment. Priority should be given to the use of resistant cultivars and chemical control should be considered only to protect susceptible but high yielding cultivars.

Results of trials conducted by researchers at the ARC-SGI indicated that treating susceptible wheat cultivars with fungicides would be profitable when disease pressure was high. However, when disease levels were low, the yield response of a susceptible cultivar was not significant, suggesting that fungicides should be applied only when it is likely that significant disease levels would develop. In most cases, yields of fungicide-treated resistant cultivars were not significantly higher than the untreated control. In some instances, treatment of resistant cultivars resulted in a financial loss.

Time of application is also an important factor that determines profitability of fungicides. Generally, higher yields and profits were obtained following two fungicide applications (at the seven leaf and flag leaf stages) compared with single applications.

**Volunteer wheat:** In the absence of wheat during the off-season, stem rust spores can infect and survive on volunteer wheat. These are self-sown wheat plants that can grow from seed dropped during the harvesting of wheat planted in the previous season. They usually grow inside or at the borders of a field. They can also grow on roadsides from seed spilled during transportation. At the beginning of the planting season, infected volunteer wheat may produce urediospores that can be wind-blown into and infect nearby wheat fields. Eradication of volunteer wheat is, therefore, important to reduce the risk of severe infection on the newly planted wheat crop.

For further information, contact Dr Terefe on 058 307 3440 or TerefeT@arc.agric.za.