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Wheat fusarium head blight: Pathogenesis and mitigation measures

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Introduction

One of the main basic foods on the earth is wheat. Over the past 40 years, significant yield improvements in wheat production have led to a consistent equilibrium between supply and demand. To fulfil this rising demand, however, significant yield increases will be required over the course of the next few decades due to expected rates of world population expansion and dietary changes. Better treatment of fungus-incited illnesses, which can result in annual output losses of 15% to 20%, is essential to overcoming this problem. Rusts, blotches, and head blight/scab are prominent wheat diseases that now contribute to these losses. Wheat blast and spot blotch, two more recently discovered or comparatively unknown diseases, respectively, pose a danger to grain output.

The Ascomycete Fungus *Fusarium graminearum* (Fg) is the main cause of the Fusarium head blight (FHB) disease, which also goes by the names wheat scab or ear blight (Fig. 2). There are several geographically distinct species complexes that can interact with other cereal-infecting Fusarium species to produce severe FHB outbreaks (Brown & Proctor (2013); http://scabusa.org/). FHB is the most harmful and devastating floral disease of wheat in the world. Severe FHB outbreaks happen at least every fourth or fifth year in the USA, China, the EU, UK, Africa, Brazil, and other places. Between the early 1990s and 2008, it was calculated that FHB-related yield losses in the USA cost US$ 3 billion (Schumann & D'Arcy, 2009). Wheat crops are especially vulnerable to FHB if rain falls during crop anthesis and the days leading up to it. The main effects of FHB disease are threefold: reduced grain yield and quality, which jeopardises the harvest as a whole and subsequent marketability; additionally, the build-up of various sesquiterpenoid trichothecene mycotoxins [such as the type B toxin deoxynivalenol (DON)] in the grain poses a significant threat to food safety and poses health risks to people,

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animals, and ecosystems. Mycotoxin levels that are acceptable for different end purposes are constrained by law in several nations. For instance, the allowable amounts for unprocessed items for human consumption in the EU and the USA are 1250 and 2000 ppb, respectively, and between 200-750 and 1000 ppb for completed products (http://scabusa.org).

Figure 2: The figure showing the symptom of the disease

Symptoms of the disease

Premature bleaching of one or more spikelets or the entire immature wheat head is a defining feature of the scab. Anywhere on the head can experience bleaching, which can then spread until the entire head is bleached. Bleached spikelets either have shrivelled and/or discoloured seed or are infertile.

On bleached spikelets, a white, pink, or orange fungal growth with orange spore masses may be seen under humid circumstances. The term "scab" comes from the sexual blue-black fruiting structures that can also develop, giving the head a scabbed look. Within three days of infection, blight

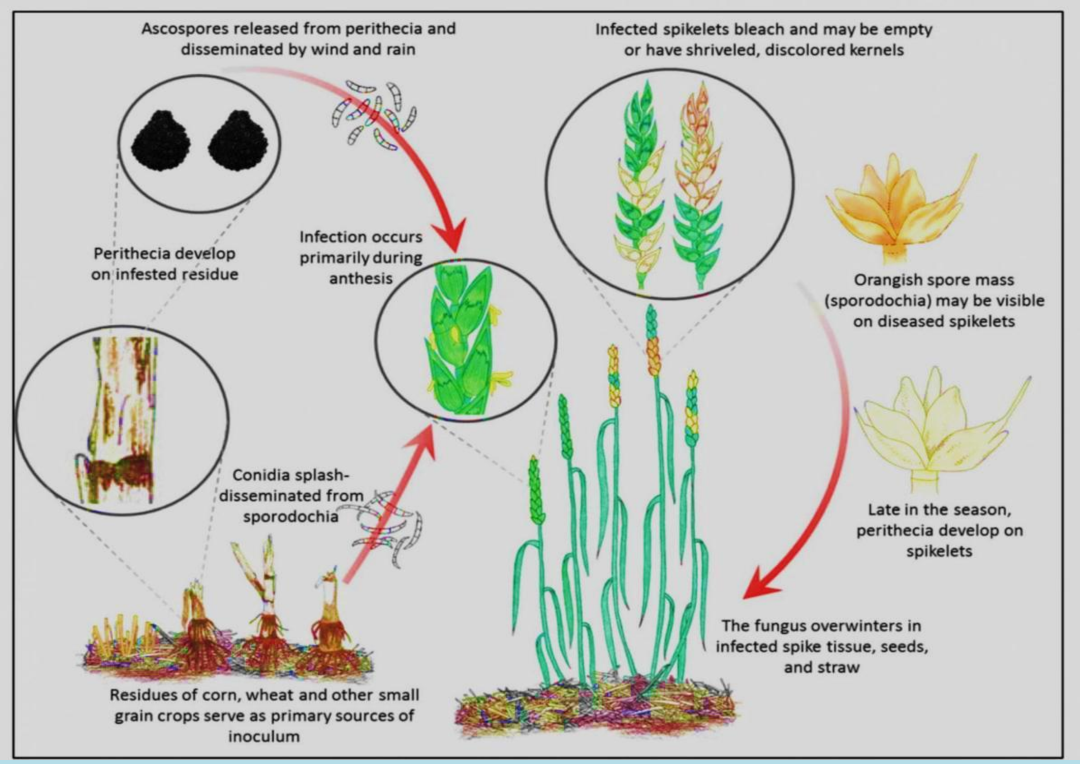

Figure 1: Showing the life cycle of the Fusarium Head Blight disease

symptoms on heads start to show in warm conditions (77°F to 86°F). The grain of scabby wheat is frequently shrivelled and/or a chalky white appearance. Severe seedling blight may develop if this grain is planted as crop seed the next year.

FHB management techniques

Only a tiny portion of wheat chromosome 3BS, home to the Fhb1 main QTL that confers FHB resistance, has been thoroughly studied from a molecular and functional standpoint. Early research suggested that the DON-glucosyltransferase implicated in DON detoxification may be encoded by or expressed under the control of the Fhb1 gene (Lemmens et al., 2005). Recent research has revealed that FHB resistance, which is unrelated to DON detoxification, is mostly influenced by a single gene in the Fhb1 locus that encodes a pore-forming toxin-like protein (PFT) (Rawat et al., 2016). However, at least two known but unpublished investigations have shown that additional gene types found in the Fhb1-containing QTL may possibly be involved in host resistance.

The most economical management method for FHB is genetic-based resistance, but it is sluggish and difficult to develop in superior commercial wheats (Wegulo et al., 2015). Only a few number of unconnected sources of moderate resistance have been found thus far, such as the cultivars Frontana from Brazil and Sumai-3 from China. Numerous main and minor QTLs, many of which are connected to a fitness cost or yield penalty, regulate FHB resistance (Gilbert & Haber, 2013). Type I (resistance to initial infection) and Type II (resistance to the propagation of FHB in the host) are the two commercially significant kinds of FHB resistance (Schroeder & Christensen, 1963).

In Europe, fungicides are a crucial component of the plan for controlling the FHB disease. However, due of Fg's inherent resistance to triazoles, triazole (DMIs) mixes used during the ideal crop blooming time can only give 30% to 60% FHB control (Fan et al., 2013). When bad weather prevents treatments, fungicide effectiveness is significantly diminished. The efficient treatment of both early- and late-flowering tillers with a single application faces technological difficulties as well.

Tillage is one cultural activity that is used to bury crop remnants that are contaminated, stopping the growth of new ascospores. Utilizing non-host plants in crop rotation might lessen DON build-ups and FHB intensity. For instance, the DON concentration in harvest grain in cycles with soybeans and wheat was 25% lower than in rotations with wheat and wheat, and 49% lower than in rotations with maize and wheat. Before harvest, the mature crop can also be allowed to stand on the field to remove any mycotoxins. Grain cleaning is a post-harvest procedure used to remove damaged, pink, or light-coloured grains, which are known to contain the greatest levels of mycotoxin.

Recently, host-induced gene silencing (HIGS) has become a unique transgenic strategy for controlling FHB (fig. 3) (Koch & Kogel, 2014). This method involves expressing lengthy double-stranded or hairpin RNAs in transgenic plants that have sequences that are similar to the coding areas of Fg critical genes. This causes the plant's RNA silencing machinery to produce tiny interfering RNAs (siRNAs). The latter may penetrate fungal cells and are mobile; once inside, they start the sequence-specific destruction of their target fungus mRNA.

The Tri5 gene and certain members of the chitin synthetase gene family are chosen Fg HIGS targets. In particular, the study by Cheng et al. (2015) showed the strong potential of HIGS to minimise mycotoxin contamination and FHB illness in field circumstances.

Studies on functional and comparative genomics are being aided by the advent of high throughput technologies, which may help to find most of the FHB sensitive genes on the crop's genome. This is due to the ability to properly sequence or profile the whole genome and transcriptome, which enables comparison of the stress responses of FHB vulnerable and resistant plants using either the same or different species or genera. Jia et al. (2009) showed variable expression of several

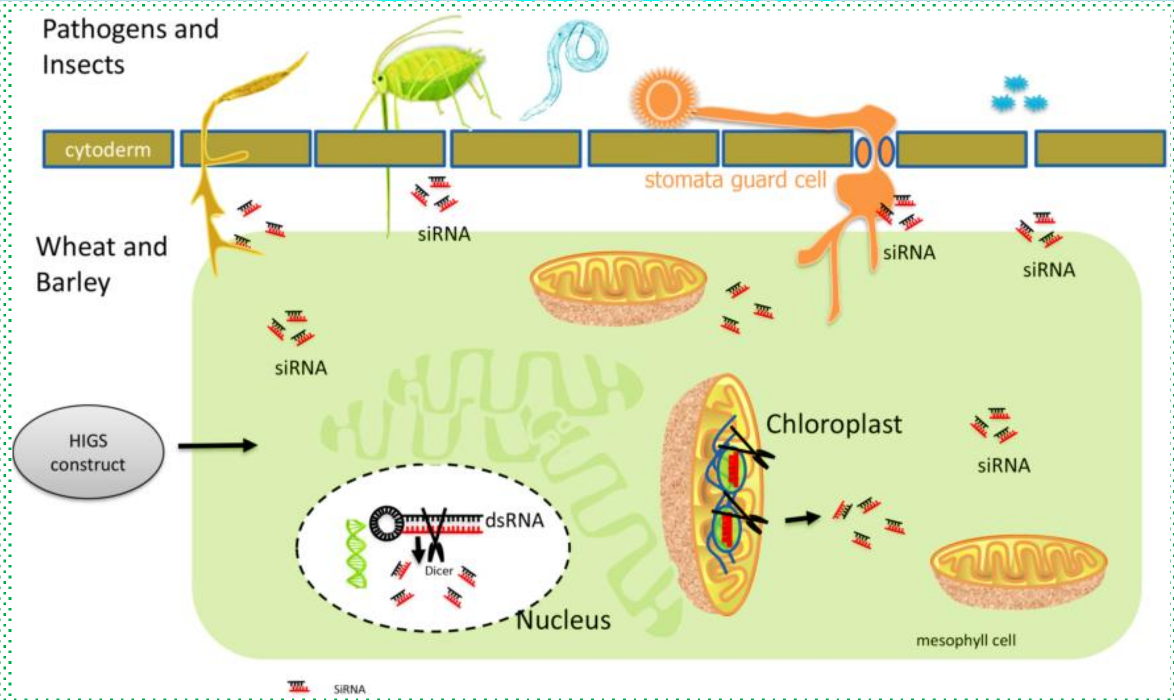

Figure 3: For managing FHB, host-induced gene silencing (HIGS) has emerged as a distinctive transgenic technique

transcripts but significant levels of conservation in the accumulation patterns of the transcriptome between wheat and barley infected with F. graminearum. These results support the notion that comparative genomics employing various cereals can reveal certain degrees of collinearity and syntheny on cereal genomes.

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