PLANT DEFENCE

Hijacking a fungal gene

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Credit: Nigel Cattlin / Alamy Stock Photo

Wheat production is threatened by the devastating fungal disease *Fusarium* head blight (FHB). The pathogens, *Fusarium* species, produce food toxins known as trichothecenes that cause immunotoxicity and cytotoxicity in human and animals, and contaminate cereal grains. So far, only a limited number of strains in the global wheat germplasm harbour FHB-resistant genetic resources, among which is a quantitative trait locus, *Fhb7*, introduced from a wheat wild relative, either *Thinopyrum elongatum* or *Thinopyrum ponticum*. Hongwei Wang, from Shandong Agricultural University of China, and colleagues reported a glutathione S-transferase (GST) as the candidate gene for the *Fhb7* locus and revealed the functional and evolutionary mechanisms of this FHB resistance gene.

To facilitate gene cloning, the researchers combined short- and long-read sequencing, BioNano optical mapping and Hi-C technologies to produce a high-quality chromosomal scale genome of *T. elongatum*, which was annotated with 44,474 protein-coding genes. With map-based

cloning and RNA-seq data, the *Fhb7* gene was narrowed down to a single GST that is present in the distal end of chromosome 7E. The candidate gene is constitutively expressed in multiple tissues. Virus-induced gene silencing and transgenic experiments supported the hypothesis that this gene confers resistance to *Fusarium*.

Surprisingly, *Fhb7*'s homologues were not detected in the entire plant kingdom but were found in the genome of *Epichloë* species, a genus of endophytic fungi, suggesting that *Fhb7* might have been acquired by horizontal gene transfer.

The expression of *Fhb7* is induced by deoxynivalenol (DON), a type of trichothecene mycotoxin produced by *Fusarium*. Wheat seedlings and yeast carrying the *Fhb7* gene grow better in media containing DON than those without *Fhb7*, suggesting that the GST enzyme detoxifies DON, which has an epoxy group known to underpin its toxicity. Chemical analysis revealed that the *Fhb7* enzyme catalysed the formation of a glutathione adduct that is de-epoxidated and consequently detoxifies DON. In fact, the *Fhb7* enzyme can catalyse and detoxify a broad spectrum of trichothecene mycotoxins produced by different *Fusarium* species. *Fhb7* transgenic plants exhibited resistance to multiple *Fusarium* species that generate various mycotoxins, including *F. pseudograminearum*, which causes crown rot. This understanding of the detoxification mechanism paves the way for the application of this GST enzyme in the biomedicine and food industries.

Incorporating the *Fhb7* gene into different wheat genetic backgrounds increases resistance to both FHB and crown rot without yield penalties, supporting *Fhb7* as an ideal gene for breeding *Fusarium* resistance in wheat and other cereal crops.

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