Wheat hybrid necrosis gene Ne2 provides leaf rust resistance and valuable for breeding new cultivars

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New wheat cultivar KM1609 containing Lr13/Ne2. Credit: IGDB

Leaf rust caused by Puccinia triticina Eriks. (Pt) is a destructive foliar disease that threatens world wheat production. Breeding and deployment of resistant cultivars are the most profitable and environmental friendly

method to prevent disease losses. It was found that when the wheat leaf rust resistance gene Lr13 was introduced into some wheat varieties by hybridization, the hybrid necrosis was often caused in F1 plants. Complementary wheat genes Necrosis 1 (Ne1) and Necrosis 2 (Ne2) on chromosome arms 5BL and 2BS, respectively, cause hybrid necrosis. Ne2 shows extremely tight genetic linkage with leaf rust resistance gene Lr13. However, the function and relationship of Lr13/Ne2 remained unknown for decades.

Recently, in a collaboration work led by Prof. Li Zaifeng at College of Plant Protection, Hebei Agricultural University and Prof. Liu Zhiyong at the Institute of Genetics and Developmental Biology of the Chinese Academy of Sciences, scientists identified wheat leaf rust gene Lr13/LrZH22 and hybrid necrosis gene Ne2/els1, and revealed that they are the same gene exhibiting pleiotropic effects.

This research provides not only a new insight on the relationship between disease resistance and hybrid necrosis, but also excellent gene resource for breeding new wheat varieties.

The Chinese elite wheat cultivar Zhoumai 22 (ZM) was effective against most Chinese Pt pathotypes and more resistant at 25 degrees Celsius than at 22 degrees Celsius and 18 degrees Celsius. The researchers isolated the high-temperature leaf rust resistance gene LrZH22 from Zhoumai 22 using map-based cloning, MutRenSeq, EMS mutagenesis, transgenic validation, and haplotype analysis. LrZH22 encodes a NLR protein containing 1,072 amino acids with Rx-CC-like, NBS and LRR domains. Wheat lines Manitou and RL4031 with Leaf rust resistance gene Lr13 shared an identical NLR gDNA sequence, indicating that LrZH22 is Lr13.

Meanwhile, they found the early leaf senescence 1 (els1) gene shared an overlapping interval with LrZH22/Lr13, co-segregating with the NLR.

RNA-seq and sequence analysis showed the NLR is an important candidate gene of els1. Sequence comparison displayed that the NLR shared an identical sequence among M114 carrying els1, Zhoumai 22, Manitou, and RL4031 with Lr13. Further genetic hybridization experiment proved the NLR is also els1 (Ne2).

Functional marker of LrZH22/Lr13/els1/Ne2 scanning of worldwide diversified hexaploid wheat collections (650 accessions) identified 31 accessions carried the LrZH22/Lr13/els1/Ne2 allele with leaf rust resistance. It is especially noteworthy that the cornerstone parental breeding line Zhou 8425B and several elite wheat cultivars widely grown in the Northern China Plain and the Yellow and Huai River Valley Winter Wheat Zone of China, such as Nongda 212, Yannong 15, Liangxing 99, and Zhoumai 22, carry the leaf rust resistance gene LrZH22 and have made significant contributions to leaf rust control in China.

The paper, titled "High-temperature wheat leaf rust resistance gene Lr13 exhibits pleiotropic effects on hybrid necrosis," was published in *Molecular Plant* on May 7, 2021.

More information: Xiaocui Yan et al, High-temperature wheat leaf rust resistance gene exhibits pleiotropic effects on hybrid necrosis, *Molecular Plant* (2021). DOI: 10.1016/j.molp.2021.05.009

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