Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
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Plants under stress:
How rye rearranges its genes

Press Release

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Gatersleben, 03.11.2025 **Researchers at the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) and the Martin Luther University of Halle-Wittenberg have gained new insights into the genetic basis of rye reproduction. They demonstrated how plants recombine their genes and the extent to which this process is influenced by environmental factors such as nutrient deficiency. The results were published today in the journal "New Phytologist".**

The researchers investigated the genetic basis and environmental plasticity of meiotic recombination in a large rye population . They used over 500 rye plants, some of which were grown under normal conditions and some under nutrient deficiency. Material was obtained from the Federal *Ex Situ* Genebank at IPK and commercially available population varieties, and all plants were cultivated on the grounds of the 'Eternal Rye Cultivation' experiment at Martin-Luther-University Halle-Wittenberg.

Established in 1878 by Julius Kühn, this experiment is still ongoing today. Various nutrient and humus replacement systems are compared in a long series of experiments, ranging from farmyard manure and mineral complete fertilisation to areas without fertilisation. "This area was particularly well suited to the study because the nutrient deficiency had built up over a very long period, making it very stable," explained Dr. Steven Dreissig, head of the independent research group "Plant Reproductive Genetics".

The researchers collected pollen and sequenced the cell nuclei of over 3,000 sperm cells from 584 individuals. They aimed to determine the number of crossover events between the parental chromosomes and identify their positions. This process could be studied directly in pollen for the first time, i.e., where it actually takes place, and in such large numbers.

"We were able to show that plant genes mix significantly less when there is a nutrient deficiency than when nutrients are supplied in adequate amounts," says Christina Wäsch, the study's first author. "You can think of it like playing cards: if the cards are only shuffled half-heartedly, fewer new combinations are created." However, that's not all. The research team also discovered differences between plant types. While the modern cultivar remained relatively stable during the study, old varieties and wild forms were susceptible to stress, explains Christina Wäsch. "This shows that genetic diversity plays a major role in how plants cope with environmental changes."

The research team also investigated the genetic basis of recombination. "In our study, we demonstrated that the recombination rate is not controlled by a single master switch, but rather by numerous small genetic regions acting in concert," explains Dr. Steven Dreissig. More than 40 alleles and two candidate genes are now known. "We now know the areas on the chromosome where these numerous genetic switches are located, but we often do not yet know all the decisive genes."

“Nevertheless, our current study makes an important contribution to our understanding of the genetic architecture and environmental plasticity of meiotic recombination”, says Dr. Dreissig. “Unlike previous studies, which only examined individual or a few genotypes, we analysed the genetic effects in a large, genetically diverse population.” The IPK researcher believes identifying the genes that control recombination under stress could be a valuable breeding tool. “The targeted control of recombination under stress will help to accelerate the development of new, improved crops that are more resistant to adverse environmental conditions.”

Original publication:

Wäsch *et al.* (2025): Population-wide single-pollen nuclei genotyping in rye sheds light on the genetic basis and environmental plasticity of meiotic recombination. New Phytologist. DOI: 10.1111/nph.70656

Photo:

For their research, the scientists are using the site of the long-term experiment ‘Eternal Rye Cultivation’ at Martin Luther University Halle-Wittenberg. Photo: IPK Leibniz Institute/ S. Dreissig