



Prospects of breeding with CWR on wheat to enhance site adaptation and drought tolerance



Introduction

Wheat plays a vital role in Europe's food supply. However, challenges such as the demand to reduce pesticides and fertilizers, along with more unpredictable weather patterns, have made it harder to achieve consistent high yields and maintain flour quality. By incorporating crop wild relatives (CWRs) into breeding efforts, we can develop more resilient wheat varieties that deliver stable yields, superior nutritional value, and contribute to healthier diets in the future.

Objectives

Wheat varieties must adapt to evolving agricultural policies, climatic changes, and shifting consumer preferences. Farmers are increasingly seeking innovative solutions such as improved drought tolerance, enhanced nutrient efficiency, or better local adaptation—qualities that breeders aim to develop by incorporating traits from crop wild relatives (CWRs). These wild relatives often possess unique resilience traits not found in modern varieties. Three

main challenges emerge: first, identifying CWRs with beneficial traits; second, introducing these traits into high-yielding and high quality elite varieties; and third, determining the farming systems and environments where these traits are most effective. The COUSIN project maps which CWR alleles benefit specific cropping systems and climates, enhancing future wheat production through careful selection under field conditions.





Results

In the COUSIN project, 3 CWRs were crossed with market cultivars in 1999, resulting in 4 distinct populations. They were grown for a first period for more than 20 generations in two different environments: an organic and a conventional farming system, conducted by the University of Bonn. This adaptation process was based solely on natural selection. The genetic heterogeneity and the long time-span in two divergent farming systems resulted in 8 distinctly adapted populations. In the second period, the yield performance of all 8 populations was examined in three years described by substantial drought from the flowering to the ripening stage. The performance trials showed that populations adapted to organic farming had higher drought tolerance and yielded more than those adapted to conventional farming, in both organic and conventional systems.

Further readings

- COUSIN project website, <https://cousinproject.eu/>
- LiveSeeding project page, <https://liveseeding.eu/>
- University Bonn, Plant Breeding, <https://www.uni-bonn.de/de/neues/107-2024>
- Schneider, M., Ballvora, A. & Léon, J. Deep genotyping reveals specific adaptation footprints of conventional and organic farming in barley populations—an evolutionary plant breeding approach. *Agron. Sustain. Dev.* 44, 33 (2024). <https://doi.org/10.1007/s13593-024-00962-8>
- Allard, R. W., and S. K. Jain. “Population Studies in Predominantly Self-Pollinated Species. II. Analysis of Quantitative Genetic Changes in a Bulk-Hybrid Population of Barley.” *Evolution*, vol. 16, no. 1, 1962, pp. 90–101. JSTOR. <https://doi.org/10.2307/2406269>
- Ceccarelli, S. Specific adaptation and breeding for marginal conditions. *Euphytica* 77, 205–219 (1994). <https://doi.org/10.1007/BF02262633>
- R. W. Allard, Genetic Changes Associated with the Evolution of Adaptedness in Cultivated Plants and Their Wild Progenitors, *Journal of Heredity*, Volume 79, Issue 4, July 1988, Pages 225–238,
- The respective publication of the described wheat populations – still under review.
Schneider, M., Ballvora, A., Döring, T. F., Messmer, M.M., Léon, J., Alleles from crop wild relatives accumulated by long-term adaptation to low-input environments contribute to yield advantages in wheat, under review in *Plant Breeding*.

Selection in low-input environments can lead to more stable yields under stress, due to adaptation for improved nutrient uptake and water-use efficiency. COUSIN partners use these adapted populations and knowledge from previous projects (e.g. LiveSeeding) as a basis for single-line selections, crossings, population improvement, and local testing. The goal is to develop resilient wheat varieties adapted to sustainable farming systems.

Recommendations

The conducted adaptation of CWR-enriched populations over a long period, together with a yield trial under drought stress, highlights the value of CWR alleles for the breeding of resilient varieties. The environment in which the selection is performed plays a crucial role, emphasizing the importance of the local ecosystem on the breeding and selection success.