The effects of whole genome duplication on the plant metabolome

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Close-up of the duckweed species Spirodela polyrhiza, seen from above on the surface of a pool. Credit: Christian Fischer/Wikimedia Commons, CC BY-SA

Whole genome duplication (WGD) is a common mutation in plants with profound evolutionary potential. While it is well-known that an increase in genetic material can lead to larger cell sizes, the impact of gene dosage multiplication on the metabolome remains largely unexplored.

Researchers from the VIB-UGent Center for Plant Systems Biology have now studied this impact in greater duckweed, Spirodela polyrhiza. Their results are published in the *American Journal of Botany*.

Genetic mutations are fundamental to adaptation and evolution. Whole genome duplication (WGD) is one of the most spectacular changes, though relatively common in plant evolutionary history. WGD results in much more than just an increase in gene numbers. The duplication of entire sets of interacting genes significantly affects dosage-sensitive pathways, offering vast potential for metabolomic diversity by increasing the gene "products" available.

Metabolites, the direct products of cellular metabolism, are crucial links between the genotype and complex phenotypes. They play roles in numerous biotic and abiotic interactions, such as gamete production, pollinator attraction, wound repair, structural support, and protection against environmental stresses like salt, drought, and UV radiation.

Throughout evolution, a conserved set of primary metabolites and hormones has been essential for plant growth and development. Given their diverse functions, metabolomic changes and novelties hold high evolutionary potential. However, the impact of polyploidization on these metabolomic changes remains largely unknown.

"The immediate effects of polyploidy are poorly understood. Theoretical explanations for immediate WGD-induced metabolomic change are almost exclusively focused on the increase in gene dosage. It is challenging to align theoretical expectations—normalized per cell—with empirical data, normalized per dry mass.

"Bridging this gap between theory and observations will lead to a better understanding of the immediate phytochemical effects of WGD," says study leader Yves Van de Peer.

The team used discovery metabolomics to investigate the immediate effects of WGD on the metabolome of greater duckweed, Spirodela polyrhiza. Previous research indicated that WGD affects cell size and cell density per unit of biomass. To clearly assess the effect of gene dosage, normalization per cell was applied, leading to the first evaluation of dosage effects per cell at the metabolome level.

The research demonstrated that the average metabolite abundance per cell increases, although there is considerable variation in the response of individual metabolites. However, this dosage effect is somewhat balanced by the inherent cell size effect of polyploidy. The researchers confirmed that WGD induces quantitative and, to a lesser extent, qualitative changes in the metabolome.

"To fully understand the immediate effects of polyploidization we need to focus more on the cell-level impacts, particularly related to cell size. Technologies like spatial transcriptomics and single-cell omics have tremendous potential to study these cell-level impacts," says Quinten Bafort.

More information: Tian Wu et al, The immediate metabolomic effects of whole-genome duplication in the greater duckweed, Spirodela polyrhiza, *American Journal of Botany* (2024). DOI: 10.1002/ajb2.16383

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