

# Increasing crop yields by breeding plants to cooperate

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A century of breeding progress has improved maize varieties such that they can be more effectively packed into high-density fields, thus increasing yields per crop area. Neighboring fields of the Swiss traditional maize landrace “Rheintaler Ribelmais” (left) and a modern elite variety (right). Credit: Samuel Wuest (CC-BY 4.0, [creativecommons.org/licenses/by/4.0/](https://creativecommons.org/licenses/by/4.0/))

A simple breeding experiment, combined with genetic analysis, can rapidly uncover genes that promote cooperation and higher yields of plant populations, according to a new study published November 29 in the open access journal *PLOS Biology*, by Samuel Wuest of the University of Zurich and Agroscope, Switzerland, and colleagues. The results have the potential to quickly increase crop productivity through

conventional breeding methods.

In classic evolutionary theory, individuals compete, and those with the most competitively advantageous genes create more offspring that bear the same winning genes. This poses a challenge for [plant breeders](#), who are often faced with selecting plants that cooperate, rather than compete. In a dense monoculture stand of corn or wheat, overall yield may be improved if individuals avoid growing too tall or spreading their leaves too wide (the "Green Revolution" of the mid-20th century was largely dependent on the introduction of dwarfing alleles into major cereal grains).

Discovering the alleles (versions of genes that differ between individuals) that may promote cooperation is challenging, but the authors designed a system to reveal them. In alignment with [game theory](#), the authors reasoned that the most cooperative genotype will perform best with similarly cooperative neighbors, but will do poorly when facing selfish, highly competitive neighbors.

They used the model plant *Arabidopsis* to compare the performance of a given plant when grown with another genetically similar individual (modeling a monoculture) to its performance when grown with a set of "tester" genotypes, that varied in their growth strategies. By determining both the overall vigor of each plant (as measured by above-ground biomass) and the difference between its growth in the two situations, they could see which plants maximized both the ability to grow rapidly and the ability to cooperate with genetically similar individuals so that their neighbors also grew well.





Arabidopsis plants grown across different social environments, i.e., in pots containing different neighboring genotypes. Credit: Samuel Wuest (CC-BY 4.0, [creativecommons.org/licenses/by/4.0/](https://creativecommons.org/licenses/by/4.0/))

With that data in hand, they used published genome-wide polymorphism data to find the [genes](#) associated with the cooperative trait. They found it was most strongly associated with a small group of linked polymorphisms, and in particular a minor allele at one gene. When plants carrying that minor allele were grown in [close proximity](#), they collectively produced 15% more biomass when grown at high density than plants carrying the major [allele](#) at the same locus. The cooperative effect was accompanied by reduced root competition—adjacent plants



may have spent less energy invading their neighbors' root zones for nutrients.

The same comparative strategy could be used for discovering cooperative alleles for any measurable characteristic, Wuest said. "Such variation, once identified in a crop, could rapidly be leveraged in modern breeding programs and provide efficient routes to increase yields."



Researchers use greenhouses to tease out cooperator genes and increase plant group yields. Credit: Samuel Wuest (CC-BY 4.0, [creativecommons.org/licenses/by/4.0/](https://creativecommons.org/licenses/by/4.0/))

Wuest adds, "The ideas that inspired this work are not new, many have in fact been formulated decades ago. And yet, the thought that we humans, one of the most cooperative species, can profit from making our crops more cooperative, too, still intrigues us today."

**More information:** Increasing plant group productivity through latent genetic variation for cooperation, *PLoS Biology* (2022). [DOI: 10.1371/journal.pbio.3001842](https://doi.org/10.1371/journal.pbio.3001842)

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