Crops grown together cooperate better in just two generations

September 13 2022

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Growing multiple food crops together is a more sustainable farming practice mimicking highly productive wild plant communities. This process, known as intercropping, takes advantage of complementary

features of different types of crops to maximize production and minimize the need for fertilizers and other environmentally harmful practices. For example, indigenous people in North America have long grown corn, beans and squash together to maximize the yield of each plant and reduce the need for watering or fertilizer.

"Most commercial crops, however, have been bred for traits that make them highly productive in single-crop settings," explains lead author Laura Stefan, a former Ph.D. student at ETH Zurich and now a postdoctoral researcher at Agroscope, the Swiss Confederation's Institute for Agricultural Research. "These crops may not be well suited for growing in multi-crop systems, which may reduce the benefits of intercropping."

To learn more about different crops' ability to adapt, the team grew wheat, oat, lentil, flax, camelina and coriander species in small plots. The plots included 13 combinations of two species, four mixtures of four different species, plants growing individually or in single-species parcels, in fertilized or unfertilized plots. The team repeated the experiments for three consecutive years, each year using seeds collected from the plots of the previous year to assess the generational effects of growing in different systems. In the third year, they measured the plants' traits and productivity.

They found that plants grown in the same multi-crop setting for two generations adapted to compete less and cooperate more with each other. However, the yield advantage of these multispecies crops compared to monoculture crops was only increased in fertilized plots. Over two generations, plants grown together in either monocultures or mixed-species plots grew taller. They also produced "cheaper", or thinner leaves, indicating a growth strategy associated with rapid biomass production.

"Our study shows that annual crops rapidly adapt to be more cooperative over just two generations, but this doesn't lead to increased yield advantages without fertilizer," says co-author Nadine Engbersen, who worked on the study as a Ph.D. student at the Institute of Agricultural Sciences at ETH Zurich, Switzerland. "Unexpectedly, the plants all grew to have more similar traits rather than specializing to fill a unique niche."

The authors suggest that the short time frame of the study—over just three years—may explain why more differentiation did not occur. It is unlikely that many genetic changes happened during that time. However genetic selection of particular genotypes might have occurred for those species with existing genotypic variation. Furthermore, epigenetic modifications that turn genes on or off may explain some of the observed plant adaptations. Microbes or nutrient resources passed from one plant generation to the next via seeds may also explain some of these rapid adaptations.

Longer-term studies may observe more adaptations caused by genetic mutations or genetic recombination, the rearrangement of plant DNA sequences. The current results suggest selective breeding could give rise to traits that optimize cooperation and yield in multispecies plots.

"Our findings have important implications for the shift to more diversified agriculture," concludes senior author Christian Schöb, Head of the Agricultural Ecology Group, previously at ETH Zurich and now at the University Rey Juan Carlos. "They suggest breeding plants to grow in mixed-species plots may further improve yields and reduce the need for fertilizer and other harmful practices."

The research was published in *eLife*.

More information: Laura Stefan et al, Rapid transgenerational adaptation in response to intercropping reduces competition, *eLife*

(2022). DOI: 10.7554/eLife.77577

Provided by eLife