

Newly discovered plant gene could boost phosphorus intake

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Credit: University of Copenhagen

Researchers from the University of Copenhagen have discovered an important gene in plants that could help agricultural crops collaborate better with underground fungi—providing them with wider root networks and helping them to absorb phosphorus. The discovery has the potential to increase agricultural efficiency and benefit the environment.

It is estimated that about 70 percent of [phosphorus fertilizer](#) used in Danish agriculture accumulates in soil, whereas only 30 percent of it reaches [plants](#).

Quid pro quo—that's how one might describe the 'food community' that the majority of plants have with mycorrhizal fungi. Plants allow fungi to live among their roots, while feeding them fat and sugar. And in return, fungi use their far-reaching hypha (filamentous branches) to capture vital soil nutrients for plants, including the important mineral phosphorus.

Now, researchers at the University of Copenhagen's Department of Plant and Environmental Sciences have discovered an extraordinary plant gene, the CLE53 gene, which regulates cooperation between fungi and plants. The gene is central to a mechanism that controls how receptive plants are to working with mycorrhizal fungi. Down the road, this newfound knowledge could serve to deliver better harvests and reduced fertilizer use.

"Similar [genes](#) are found in all plants—including [agricultural crops](#). So, by mutating or turning off the CLE53 gene in a crop plant, it is more likely for a plant to become symbiotically involved with a fungus. In doing so, it becomes possible to reduce the need for phosphorus fertilizers, as plants improve at absorbing preexistent phosphorus from soil," explains Assistant Professor Thomas Christian de Bang of the Department of Plant and Environmental Sciences.

The research has been published in the *Journal of Experimental Botany*

Seventy percent of phosphorus fertilization does not reach plants

Phosphorus is vital for all plants. However, the problem with phosphorus use in agriculture is that more of it is applied for fertilization than can be absorbed by crops. It is estimated that about 70 percent of phosphorus fertilizer used in Danish agriculture accumulates in soil, whereas only 30 percent of it reaches plants. With rain, there is an ever present risk that some of the accumulated phosphorus will be discharged into streams, lakes and the sea.

Paradoxically, researchers have observed that when phosphorus levels in soil are high, plants are less likely to collaborate with fungi, meaning that they become worse at absorbing nutrients.

"Through a range of experiments, we have demonstrated that a plant does not produce the CLE53 gene if it lacks phosphorus. However, when the phosphorus levels in a plant are high, or if the plant is already symbiotically involved with a fungus, then the level of CLE53 increases. Our study demonstrates that CLE53 has a negative effect on a plant's ability to enter into symbiosis with a fungus, and thereby absorb phosphorus most effectively," says Thomas Christian de Bang.

Requires CRISPR approval

The genomic editing of plants is legal in a number of non-EU countries—e.g., China, the US, Switzerland and the UK. However, within the EU, there is no general acceptance of gene-editing methods, such as CRISPR, to alter plants and foodstuffs.

Therefore, the researchers' discovery has, for the time being, a poorer chance of being used in Denmark and the rest of the EU.

"One can use the technology in other parts of the world, and getting started would be relatively straightforward. My guess is that within five years, plants will be tested and refined in such a way that they become

more symbiotically involved with fungi and absorb more phosphorus. Here in Denmark and throughout the EU, an acceptance is required for gene editing and an amended approach to approval procedures for these types of plants," says Thomas Christian de Bang.

Facts:

- 90% of all plants engage in symbiotic relationships with mycorrhizal [fungi](#), which popularly said, extend the root networks of plants, thus helping them to obtain enough phosphorus, water and other nutrients.
- In order to benefit from the ability of [mycorrhizal fungi](#) to extract phosphorus from soil, a plant must feed it with fat and sugar. To avoid spending too much energy on the sponge, if for example, it is experiencing high phosphorus levels or has already been colonized by a fungus, the plant may switch off symbiosis.
- It is estimated that Danish farms fertilize with roughly 30 kilos of phosphorus per hectare of land.
- Of this, roughly 30 percent makes its way to crops, while the remaining 70 percent binds to soil.
- With rain, some of this accumulated [phosphorus](#) is flushed away via surface runoff, into nearby streams, lakes and the sea. This increases algae growth and can kill both plants and wildlife.
- Phosphorus is a finite natural resource, one that is expected to eventually be depleted.

The research is funded by the Novo Nordisk Foundation and the University of Copenhagen

Previous research has shown that a similar mechanism exists for symbiosis between legumes and rhizobium bacteria. This involved a CLE gene as well, albeit a different one than the researchers have now discovered.

More information: Magda Karlo et al, The CLE53-SUNN genetic pathway negatively regulates arbuscular mycorrhiza root colonization in *Medicago truncatula*, *Journal of Experimental Botany* (2020). [DOI: 10.1093/jxb/eraa193](https://doi.org/10.1093/jxb/eraa193)

Provided by University of Copenhagen

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