Study shows potential to reduce reliance on non-renewable fertilizers in agriculture

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An enzyme that can help release phosphorus from its organic forms has been identified in a study from the University of Sheffield's Institute for Sustainable Food, published in leading science journal *PNAS*.

The enzyme has the potential to help reduce the consumption of phosphate chemical fertilizers which global food production systems rely on, but are produced by the mining of non-renewable and increasingly expensive inorganic sources of rock phosphate.

All organisms on Earth, plants and animals, require phosphorus for healthy growth and development, but the continued use of the limited stocks of non-renewable phosphorus chemical fertilizers in agriculture threatens crop yields and the sustainability of our global food production systems. Agriculture is the biggest consumer of non-renewable phosphorus, so its limited supply has important implications for global food security, biodiversity and climate regulation.

The most simple form of phosphorus in use in fertilizers is non-renewable inorganic phosphate, as unfortunately the availability of organic phosphate nutrients in the environment is often low enough to limit natural plant and algae growth.

In the ocean and soil, most of the total phosphorus exists in complex organic forms, which requires enzymes, commonly known as phosphatases, to release the phosphate so that plants and algae can use it as a nutrient.

Researchers at the University's Institute for Sustainable Food have identified a unique bacterial phosphatase abundant in the environment called PafA, that can efficiently release the phosphate used in fertilizers from its organic forms.

The study used a Flavobacterium model to look at the PafA function in vivo and showed it can rapidly mineralize naturally occurring organic phosphate independently of phosphate level, a process which is was found to be inhibited with other common enzymes such as PhoX and PhoA phosphatases, especially if there are already residual levels of phosphate around.

Dr. Ian Lidbury, from the University of Sheffield's Institute for Sustainable Food and Arthur Willis Environmental Research Centre, says that "the accumulation of phosphate can inhibit enzyme activity in the most common phosphatases, but PafA is unique in that its function does not suffer when phosphate accumulates."

"As there is a high occurrence and diversity of PafA in the environment, both on land and aquatic environments, this makes it a valuable overlooked resource for finding ways to help plants and animals more efficiently capture essential nutrients, and will be crucial to help us reducing our reliance on—and the damage caused by rapidly using up—the world's limited stocks of non-renewable chemical phosphorus fertilizers."

"Our further research will investigate how PafA functions, as Flavobacterium forms appear to be particularly active compared to others. So understanding this is crucial for us to be able to engineer optimized enzymes for use in agriculture."

The team are now working to investigate what makes certain forms of PafA more active than others, with the goal of designing an enzyme that can be used to promote sustainable agriculture, through providing more readily available organic sources of phosphorus for plants, with the potential to introduce it into animal feeds.

More information: Ian D.E.A. Lidbury et al, A widely distributed phosphate-insensitive phosphatase presents a route for rapid organophosphorus remineralization in the biosphere, *Proceedings of the National Academy of Sciences* (2022). DOI: 10.1073/pnas.2118122119

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