Mathematical study of photosynthesis clears the path to developing new super-crops

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How some plant species evolved super-efficient photosynthesis had been a mystery. Now, scientists have identified what steps led to that change.

Around three per cent of all plants use an advanced form of photosynthesis, which allows them to capture more carbon dioxide, use less water, and grow more rapidly. Overall this makes them over 50%

more efficient than plants that use the less efficient form.

A new study has traced back the evolutionary paths of all the plants that use advanced photosynthesis, including maize, sugar cane and millet, to find out how they evolved the same ability independently, despite not being directly related to one another.

Using a mathematical analysis, the authors uncovered a number of tiny changes in the plants' physiology that, when combined, allow them to grow more quickly; using a third as much water as other plants; and capture around thirteen times more carbon dioxide from the atmosphere.

Together, these individual evolutionary advances make up a 'recipe' that could be used to improve key agricultural crops that only use the less efficient form. The study's authors say this knowledge could be used to breed super-crops such as faster growing, drought-resistant rice.

The research was led by mathematician Dr Iain Johnston from Imperial College London and plant biologist Dr Ben Williams from the University of Cambridge, and is published in the journal *eLife*. They came together to test whether a new mathematical model of evolution could be used to unpick the evolutionary pathways that led to the advanced photosynthesis.

"My main interest is in using tools from maths to make some concrete progress in a problem of real biological and social value," said Dr Johnston. "Encouragingly for the efforts to design super-efficient crops, we found that several different pathways lead to the more efficient photosynthesis – so there are plenty of different recipes biologists could follow to develop to achieve this."

Dr Julian Hibberd from the University of Cambridge, the final author on the paper, added: "This is not only an interesting mathematical result, it should help biological scientists to develop crops with significantly improved yields to feed the world. Like the proverbial roads that all lead to Rome, Ben and Iain have shown that there are many routes taken by plants in the evolutionary process."

The next step for the biologists is to recreate the natural evolution of the more advanced photosynthesis by mirroring the genetic and physiological changes in simple laboratory plants, and eventually in rice.

More information: "Phenotypic landscape inference reveals multiple evolutionary paths to C4 photosynthesis" was published by Ben P Williams, Iain G Johnston, Sarah Covshoff and Julian M Hibberd in *eLife*, dx.doi.org/10.7554/eLife.00961

Provided by Imperial College London

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