Molecular signature shows plants are adapting to increasing atmospheric carbon dioxide

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Plantago lanceolata, the plantain found in the high carbon dioxide springs.

Plants are adapting to increasing atmospheric carbon dioxide according to a new study from the University of Southampton

The research, published in the journal *Global Change Biology*, provides insight into the long-term impacts of rising CO_2 and the implications for global food security and nature conservation.

Lead author Professor Gail Taylor, from Biological Sciences at the University of Southampton, said: "Atmospheric CO_2 is rising – emissions grew faster in the 2000s than the 1990s and the concentration of CO_2 reached 400 ppm for the first time in recorded history in 2013.

"On the one hand, more CO_2 is known to be good for plants, at least in the short-term because this drives up photosynthesis and plant growth including crop growth and food production. Indeed recent decades have seen the planet becoming greener as vegetation growth is stimulated as CO_2 rises.

"Until now, few reports had given us any insight into the long-term impacts of rising CO_2 over multiple generations and none have been undertaken on the molecular signature underpinning such adaptation. One reason for this is that's it's a difficult problem to crack – to find plants that have been exposed to conditions of the future, but are available today."

To address this problem, the researchers used a unique resource – naturally high CO_2 springs where plants have been subjected to more CO_2 over many hundreds of years and multiple plant generations. Taking plantago lanceolata plants from a 'spring' site in Bossoleto, Italy and comparing the molecular signature with the same plants from a nearby 'control' site (at today's CO_2) revealed striking differences in the total gene expression (the process by which specific genes are activated to produce a required protein).

Professor Taylor said: "The study shows that when we take plants from these two places that represent the atmosphere of today with that of the future (out to 2100), and place them together in the same environment, the plants from spring sites were bigger and had a better rate of photosynthesis. Most importantly, plants from the spring sites had differences in the expression of hundreds of genes.

"In particular, we predict from these gene expression data that planetary greening will continue – it won't switch off or become acclimated as CO_2 continues to rise, but some of the extra carbon in future plants is likely to go into secondary chemicals for plant defence. This is associated with more gene expression underpinning plant respiration."

One of the most interesting findings was that stomatal pores on the surface of the leaf (small holes that control the uptake of CO2 for photosynthesis and the loss of water vapour) increase in number after multi-generation exposure to future CO2. The team predicted that pore number would decline, in line with past research over geological timescales using fossil plants.



High carbon dioxide spring, with tower for measuring the concentration

Professor Taylor added: "This is a counter-intuitive finding but strongly suggests that stomatal pore numbers increase, since we have identified several key regulators of stomatal number that are sensitive to future high CO2. One of those is SCREAM (SCRM2), which is a member of the basic helix-loop-helix (bHLH) protein family that acts to regulate plant developmental transitions.

"We don't understand the full consequences of this developmental change but it shows that plants will adapt in unpredictable ways to future CO2 over multiple generations. This question is pressing – we need to know how food crops may evolve over future generations in response to the changing climate, whether planetary greening is likely to continue and the impacts of this for global nature conservation."

This research was funded by the FP7 Framework for Research Programme of the EU, as part of the EXPEER consortium 'Experimentation in ecosystem research', NERC and the British Council.

Links to external websites

'Plant adaptation or acclimation to rising CO2 Insight from first multigenerational RNA-Seq transcriptome' paper

The University cannot accept responsibility for external websites.

Related Staff Member



Professor Gail Taylor *BSc, PhD, FSB*

Professor of Plant and Environmental Biology

Professor Gail Taylor is a leader in Plant and Sustainability Science, where her research focusses on the challenges of sustainable energy and food production and adaptation of biological systems to the changing climate. She joined the University of Southampton in 1999 and has held several positions in the university including Director of Research for Biological Sciences (2012-2015) and Chair of the university-wide multidisciplinary Energy research group. She works as part of the UK Energy Research Centre, is a member of the Strategic Advisory Group for Bioenergy of the Energy Technologies Institute and sits on several international panels for research assessment including in Finland, Canada and France.

Professor Taylor has a global reputation for her research on sustainable bioenergy and leafy food crops and has published more than 130 journal articles on this topic and has trained over 45 Phd students. She is currently leading a 23 partner European consortium that aims to bring the latest molecular and DNA sequencing technologies to the development of non-food bioenergy crops for Europe including elephant grass, giant reed and poplar trees that can be grown on marginal land. Alongside this, she works internationally on the greenhouse gas balance of bioenergy cropping systems and is currently leading an EPSRC SUPERGEN project on assessing the greenhouse gas cost of UK and imported feedstocks for bioenergy. She is a Fellow of the Royal Society of Biology and in 2015 was nominated as a member of The Company of The Annals of Botany – the longest running general plant biology journal. She is Chair and Director of the Vitacress Conservation Trust – a Trust dedicated to the preservation and enhancement of chalk streams, where she focusses her own research on using genomic tools for the sustainable intensification of watercress – developing a food crop with better nutritional and health benefits whilst having a reduced environmental footprint.

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