Research briefing

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Improving photosynthesis to increase food and fuel

Dr Erik Murchie, School of Biosciences

Producing enough safe and affordable food for a growing population while reducing our dependance on fossil fuels is one of the biggest global challenges of the future. Dr Erik Murchie, an expert in crop physiology at The University of Nottingham, is playing a lead role in a £2m national study aimed at increasing crop yields.

A global challenge

A growing global population and changing patterns of land use means that world food production rates will have to increase by at least 50% by 2050. Dwindling fossil fuels mean we need to identify alternative renewable alternatives urgently.

Researchers — including Dr Erik Murchie, an expert in crop physiology at The University of Nottingham — are looking at how better harnessing the energy of the sun could improve crop yields. It is hoped that this research will lead to a significant boost in crop yields for food, bioenergy and the production of renewable chemicals.

Dr Murchie has a lead role in a £2m study to overcome some of the fundamental limitations of photosynthesis – the process used by plants to harvest energy from the sun.

His study — **Removing the inefficiencies of 3-dimensional canopy photosynthesis by the manipulation of leaf light response dynamics and architecture** — is one of five projects announced by the **Biotechnology and Biological Sciences Research Council** (BBSRC), which will share just over £2m.

The projects complement four funded last year via an Ideas Lab in collaboration with the National Science Foundation in the USA. Together, these nine research projects span the whole photosynthetic pathway, from the shape of the crop canopy and the structure of individual leaves through to light capture at the molecular level and the production and storage of sugars.

Dr Murchie studies the factors that regulate photosynthesis in crop plants. His work will focus on removing the inefficiencies of 3-dimensional canopy photosynthesis by the alteration of leaf light-response dynamics and plant architecture.

He said: “We hope to take good 3D images of crop canopies, w

Productivity of photosynthesis

Photosynthesis varies according to species, climate, growth conditions and ‘stress’ levels and is dependent on a second-to-second timescale on (for example) light and temperature. For decades, crop scientists have ignored small changes and studied photosynthesis over long periods to measure it. Future global food security demands a more detailed examination to understand how small-scale changes can influence canopy photosynthesis and yield.

A canopy is a population of leaves in different photosynthetic ‘states’, conferred by a leaf’s position, its age and its ‘light history’. Canopy photosynthesis will be the sum of photosynthesis in all the leaves over long periods of time. We need ways to predict which components of photosynthesis in individual leaves are causing the limitation to photosynthesis at the canopy scale. This could be **stomata**, **Calvin cycle**, quantum yield of leaves, **sucrose synthesis**. We aim to model canopies by imaging at high resolution and then use these images in advanced models that take into account the second-to-second changes in photosynthesis at every point within the canopy.

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both still and moving, calculate the typical changes in light intensity that occur in that canopy and then change photosynthetic dynamics so that it matches those changes."

Science Minister David Willetts said: "Food security is an important issue for governments and researchers worldwide, and it's great to see UK scientists contributing to such a valuable body of international research. If we can gain a better understanding of the scientific processes underlying food production, we are a significant step closer to being able to support an increasing global population in future."

Biochemist **Professor Richard Cogdell FRS**, from the University of Glasgow, acted as a mentor for the Ideas Lab and was a member of the assessment panel for this call for applications.

He said: "Trying to improve photosynthesis is challenging both scientifically in itself and because it requires the coming together of engineers, physicists, chemists as well as more traditional biologists. The new targeted programme in this area has allowed real innovative, 'out-of-the-box' projects to be explored in a very exciting way."

Global food security is a priority research area for The University of Nottingham and is part of **Impact: The Nottingham Campaign**.

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David Willetts, Science Minister

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About the author

Dr Erik Murchie is studying the factors that regulate and limit photosynthesis in crop plants. He examines the fundamental processes in crop plants such as light harvesting, carbon assimilation and energy dissipation and identify targets and strategies for improvement of crops in both optimal and suboptimal (stressful) environments.

The rate of leaf and canopy photosynthesis is important as a target for raising crop yields. We know this from studies that identify total biomass accumulation rate as a limiting factor (Murchie et al, 2009). The processes of harvesting and converting photosynthetically active radiation in plants are capable of operation with a very high efficiency at the molecular level. However the upscaling of these processes to plants, canopies and agroecosystems involves losses caused by metabolic and environmental factors and we measure this as a reduction in radiation h use efficiency (RUE)*.

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About the BBSRC

The Biotechnology and Biological Sciences Research Council is one of seven research councils that work together as **Research Councils UK** (RCUK) and is funded by the Goverment's Department for Business, Innovation and Skills.

With a 2011/12 budget of around £445m, it supports around 1,600 scientists and 2,000 research students in universities and institutes across the UK.

Its mission is to promote and support, by any means, high-quality basic, strategic and applied research and related postgraduate training relating to the understanding and exploitation of biological systems, and to advance knowledge and technology and provide trained scientists and engineers, which mee the needs of agriculture, bioprocessing, chemical, food, healthcare, pharmaceutical and other biotechnological-related industries, contributing to the economic competitiveness of the UK and the quality of life.

For more on this project, contact Mike Davies.

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