'Exciting biology' uncovers plants' high-fat diet for fungal benefactors

June 13 2017

One of biology's most enduring relationships, credited with helping plants to colonise land more than 400 million years ago, has yielded a fundamental survival secret with implications for agriculture and biotechnology.

Plant scientists have discovered that a particular form of fungi, which invades plant roots and then helps the colonised plants to absorb nutrients from soil, receive life-sustaining carbon from their symbiotic hosts in the form of long-chain fatty acids, a building block for essential lipids.

Previously, scientists had thought that the fungi received carbon from their hosts only in the form of carbohydrates, which the fungi used to make their own fatty acids and then the more complex lipids necessary for survival.

It's now clear that the main source of carbon from the host plants are fatty acids, and that these fatty acids are necessary before the fungi can create the more complex lipids that are needed for storing energy, for signalling and for cellular membranes.

The latest work, published by the journal *Science*, comes from a joint team of scientists from the John Innes Centre, based at Norwich Research Park, and Rothamsted Research. This field of science is very competitive currently, with research groups in China, Germany and the US all chasing similar breakthroughs.

Professor Giles Oldroyd, project leader in cell and developmental biology at the John Innes Centre, and co-leader of the research team said: "It has long been thought that the plant delivered sugars to the symbiotic fungi. Our research demonstrates that in addition the plant delivers lipids to the fungus. We hope that through a better understanding of these plant/fungal symbioses we may be able to improve their use in agriculture and thus increase the sustainability of agricultural systems."

The symbiotic relationship at the heart of this research, and one of the most widespread associations in nature, is that between the great majority of plants, at least 80% of them, and arbuscular mycorrhizal fungi, which create special feeding structures within the plants' roots called arbuscules.

The fungi, which develop hyphae to increase the roots' surface area, can provide the plant with up to 80% of its nutrients from soil while the plants can yield up to 30% of the carbon they derive through photosynthesis to the fungi.

Professor Peter Eastmond, senior biochemist in the Department of Plant Sciences at Rothamsted and co-leader of the research team said: "This is exciting biology. We've discovered that the fungus is effectively re-programming the plant to pump out lipids,"

"There are important implications for sustainable agriculture, particularly in nutrient-poor soils where you need to make the most of resources," said Prof Eastmond. "And also for biotechnology, in creating green pathways to produce lipids in plants, for biofuels and for precursor chemicals for industrial applications, as an alternative to fossil fuels."

Rothamsted began to investigate the relationship's metabolism in 2011 after ground-breaking genetic studies at the JIC had been the first to

identify and isolate two genes essential for sustaining the symbiosis, RAM (Required for Arbuscular Mycorrhization)1 and RAM2.

"We grappled with understanding why these genes were so important until we came up with the hypothesis that the symbiosis created a lipid factory in the plant that fed the fungus," said Prof Eastmond. "This went against what the literature said...we were proposing to overturn what's in the text books."

The team came up with a trio of robust and ingenious experiments that got around the inseparable union to distinguish whether one or both of the symbiotic partners were producing lipids. Each experiment independently endorsed the hypothesis.

"There's a lot more work to do in following up this discovery," said Prof Eastmond. "It will have a lasting impact on the understanding of the metabolism of this symbiotic relationship and lead researchers in many new directions."

More information: Fatty acids in arbuscular mycorrhizal fungi are synthesized by the host plant, *Science* (2017). DOI: 10.1126/science.aan0081

Provided by John Innes Centre