Microbe diet key to carbon dioxide release

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As microbes in the soil break down fallen plant matter, a diet "balanced" in nutrients appears to help control soil fertility and the normal release of the greenhouse gas carbon dioxide into the atmosphere.

When plants drop their leaves, stems and twigs, this organic matter slowly becomes part of the soil as a result of decomposition, which is facilitated by bacteria and other microbes. This process adds plant nutrients to the soil and releases carbon dioxide into the atmosphere.

Duke University scientists found the proportion of nitrogen to carbon in this organic matter determines how much nitrogen becomes available to plants in the soil and how much carbon dioxide is released into the atmosphere. Their study also yielded a universal mathematical formula that can predict the decomposition process anywhere in the world.

The results of the Duke analysis were published Aug. 1 in the journal *Science*.

"For the first time, we have been able to demonstrate that the pattern of carbon dioxide release into the atmosphere through decomposition is governed by the same properties everywhere, from the Arctic Circle to tropical rain forests," said first author Stefano Manzoni, a Ph.D. candidate in civil and environmental engineering who works in the laboratory of senior scientist Amilcare Porporato, associate professor of civil engineering in Duke's Pratt School of Engineering. "This provides a mathematical way of describing a critical natural process."

During decomposition, microbes digest fallen organic matter from plants and slowly break it down. Two of the important byproducts of this process are mineral nitrogen and carbon dioxide. Nitrogen is an essential nutrient for both plants and microbes, and once it becomes mineralized, it becomes available for plants to use.

Carbon -- the most abundant element in plants and organic matter -- is released into the atmosphere in the form of carbon dioxide, one of many of the so-called greenhouse gases implicated in global warning. This carbon dioxide release is known as respiration.

"One of the key findings of this study is that microbes can adapt and do fairly well in a nutrient-poor environment," Porporato said. "When their diet is lacking in nitrogen, microbes tend to react by releasing more carbon dioxide into the air and taking in less mineral nitrogen from the soil. So plants can get the much-needed mineralized nitrogen earlier in the decomposition process from the fallen organic matter."

However, he pointed out, the earlier availability of mineral nitrogen for plant use comes at a risk: nitrogen in this form in the soil becomes more vulnerable to rain, which can wash it away or leach it deeper into the soil. This would be especially true if the rainfall events are particularly heavy, as has been predicted in some climate-change models.

Maintaining enough soil nitrogen is important in both native ecosystems and in farms and orchards, the scientists said.

"Nitrogen is the element that most limits plant growth around the world," said co-author Rob Jackson, Duke professor of biology and environmental sciences. "Our work should help predict how much nitrogen becomes available when organic matter is added to the soil, either naturally or through added mulches and manures."

For the analysis, Manzoni assembled a database of more than 2,800 samples of decomposing plant matter from locations around the world in a wide spectrum of climates. As he studied decomposition across these sites, he found similar patterns of nitrogen release and respiration no matter what the climate was like.

"A diet rich in carbon causes microbes to release more carbon into the atmosphere in the form of carbon dioxide as they strive to maintain the healthy balance between nitrogen and carbon in their diet," Manzoni said. "For this reason, if more carbon is added to the soil in the form of plant residues, the microbes would then just pump out more carbon in response."

The research team plans to use the same approach to better understand the roles of other nutrients in the decomposition cycle.

Source: Duke University

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