Unexpected finding shows fungi may not help store climate change's extra carbon

August 30 2012

Fungi found in plants may not be the answer to mitigating climate change by storing additional carbon in soils as some previously thought, according to an international team of plant biologists.

The researchers found that increased carbon dioxide stimulates the growth of arbuscular mycorrhizal fungi (AMF)—a type of fungus that is often found in the roots of most land plants—which then leads to higher decomposition rates of organic materials, said Lei Cheng, post doctorate fellow in plant science, Penn State. This decomposition releases more carbon dioxide back into the air, which means that terrestrial ecosystems may have limited capacity to halt climate change by cleaning up excessive greenhouse gases, according to the researchers.

"Prior to our study, there have been few studies on whether elevated levels of carbon dioxide would stimulate organic carbon decomposition through AMF," said Cheng.

To study the effect of higher levels of carbon dioxide on AMF-mediated decomposition, the researchers conducted four experiments, two in greenhouses and two in fields to mimic the earth's expected North American atmospheric levels of carbon dioxide. They studied plots of a wild oat species, which is native to Eurasia and now common in North American grasslands, and wheat.

In the experiments, one plot was treated with AMF, the other did not have the fungus. Both plots were exposed to higher than currently existing carbon dioxide levels. After a ten-week gestation period, the sample of plants with AMF had 9 percent less carbon in the soil than the plot that was not treated with AMF, indicating that the carbon was released back into the atmosphere.

"Basically, we showed that elevated carbon dioxide increases carbon allocation to AMF to increase plant nitrogen uptake, and higher AMF facilitate organic residue decomposition which releases carbon dioxide into the air," said Cheng.

Elevated levels of carbon dioxide did significantly increase the size of the AMF colonies and carbon allocation underground, according to the researchers, who released their findings in the Aug. 30 issue of *Science*. However, the storage of carbon is offset by the role of AMF in facilitating decomposition.

"We used to think that this excess carbon would be sequestered in the soil," said Cheng. "So, that could help mitigate climate change, but it doesn't appear to be so."

They also studied the effect on a wheat and soybean field. In this experiment, Cheng said elevated levels of carbon dioxide increased both the size of AMF colonies and decomposition.

AMF colonies, which are found in the roots of 80 percent of land plant species, play a critical role in the earth's carbon cycle. The fungus receives and stores carbon—a byproduct of the plant's photosynthesis—from its host plant in its long vein-like structures. A plant stores about 20 percent of its carbon in AMF, according to Cheng.

AMF also help the plant capture nutrients, such as phosphorus and nitrogen.

"We found that, under elevated carbon dioxide levels, AMF supply more nitrogen to their host plants by acquiring ammonium directly from decomposing residues," Cheng said. "So the good news is that AMF's role in the plant's nitrogen uptake may open up the possibility of keeping carbon in the soil."

When there are higher carbon dioxide levels, the plant's ability to take in nitrates is inhibited and it then adds more carbon to fungi like AMF to acquire ammonium, said Cheng. The management of soil nitrogen transformations may provide a promising strategy of restoring levels of carbon sequestration under higher carbon dioxide conditions.

More information: Arbuscular Mycorrhizal Fungi Increase Organic Carbon Decomposition Under Elevated CO2, *Science*, 2012.

Abstract
The extent to which terrestrial ecosystems can sequester carbon to mitigate climate change is a matter of debate. The stimulation of arbuscular mycorrhizal fungi (AMF) by elevated atmospheric carbon dioxide (CO_2) has been assumed to be a major mechanism facilitating soil carbon sequestration by increasing carbon inputs to soil and by protecting organic carbon from decomposition via aggregation. We present evidence from four independent microcosm and field experiments demonstrating that CO_2 enhancement of AMF results in significant soil carbon losses. Our findings challenge the assumption that AMF protect against degradation of organic carbon in soil and raise questions about the current prediction of terrestrial ecosystem carbon balance under future climate-change scenarios.

Provided by North Carolina State University