17 PARTNERSHIPS FOR THE GOALS

Scientists join forces to study soil to find ways to reduce greenhouse gas emissions

By Nicole Jawerth

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— María Adriana Nario Mouat, researcher, Nuclear Energy Commission, Chile

Balancing the use of fertilizer, water and soil in agriculture has proven useful for reducing greenhouse gas (GHG) emissions, which drive climate change and global warming. But striking an optimal balance requires an understanding of how these factors are influenced by different soil and environmental conditions as well as farm management practices. To help chart out ways to do that, scientists are increasingly using isotopic techniques to develop scientifically based guidance that helps reduce and mitigate GHG emissions.

"In Brazil, we are already producing crops and meat using processes that help mitigate GHG emissions while having a minimal environmental impact, but we need to better understand the impact of these processes on agriculture and emission reduction," said Segundo Urquiaga, a researcher from the Brazilian Agricultural Research Corporation who has participated in an ongoing project on mitigating GHG emissions supported by the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO). "That's how working with the IAEA is helping us."

Brazil has been working with the IAEA for over 30 years to study the environmental impact of agriculture, which has generally accounted for over 35% of its GHG emissions. The country has successfully reduced GHG emissions by around 20%.

Participants at the free air carbon dioxide enrichment experiment site at the Justus Liebig University Giessen, Germany. (Photo: M. Zaman/IAEA)

The IAEA and the FAO provide a platform for scientists from around the globe to work together in the use of isotopic and related techniques to study the natural processes occurring in soil, plants and fertilizer under different climate conditions and to optimize agricultural practices to protect resources while reducing GHG emissions.

Agriculture contributes over a fifth of the global release of GHGs caused by human activity, according to the Intergovernmental Panel on Climate Change. Greenhouse gases, such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), trap heat in the Earth's atmosphere by absorbing thermal radiation from the Earth, which in turn increases the Earth's temperature. While the greenhouse effect is a natural process through which the Earth regulates its temperature and supports life, the excessive amount of GHG emissions have led to global warming.

The international community is working through agreements such as the United Nations Framework Convention on Climate Change to minimize the release of GHGs and mitigate their impact.

Learning from each other

Through these global studies, scientists expect to refine how they approach mitigation and get a better idea of how these processes work. Some countries, like Brazil, are more advanced in their research, and their experience is an important resource for those just starting out. But as each country faces unique environmental conditions and experiences, even more advanced countries can learn in the process.

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us to speed up this research process that can otherwise take years," said María Adriana Nario Mouat, a researcher from the Chilean Nuclear Energy Commission.

Reducing GHG emissions (see The Science box) related to agriculture is one central aspect of combating climate change, but it has to be done in a balanced manner, so that farmers can still produce enough food and earn a living, said Christopher Müller, a soil and plant expert from Justus Liebig University Giessen in Germany. "There are so many factors that can influence how these natural processes work from one ecosystem to the next. If we can better understand how these factors work, we could help shape agricultural practices that improve our global situation while protecting soil resources."

As the scientific data is gathered, it can be incorporated into national approaches to GHG mitigation, said Nario Mouat. "Policymakers need this information so they can make decisions on how they can mitigate these gases in a country, and also how to incentivize farmers to adopt these methods. What we are doing now is part of that process," she said.

Digging into the details

Isotopic techniques are helping scientists uncover the details of the natural processes involving soil, plants and fertilizer. These techniques involve isotopes, which are atoms of the same element that have the same number of protons, but different numbers of neutrons. Nitrogen-15 is a stable isotope of nitrogen, while carbon-13 is an isotope of carbon. Both occur naturally in soil, fertilizers, water and plants. It is possible to use these isotopes to measure and track how and when gases such as CO_2 and N_2O are formed, released and absorbed.

"Isotopic techniques are extremely precise and allow scientists to better understand what's happening at each step of the process, something that conventional techniques cannot offer," said Mohammad Zaman, a soil scientist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "This also helps in identifying how farmers can sustainably grow crops, save water and reduce the use of expensive fertilizers, all while protecting the Earth's precious resources."

Free air carbon dioxide enrichment study on permanent grassland at the Justus Liebig University Giessen, Germany.
(Photo: M. Zaman/IAEA)

Quick Facts

The estimated economic losses due to nitrous oxide released from chemical fertilizer amounts to around $469 million per year.

THE SCIENCE

Managing greenhouse gas emissions

Soil is a mixture of minerals, organic matter, gases and water. Carbon is a key ingredient of soil structure and health, but, in gaseous form, it is a significant part of GHG emissions. Plants capture carbon in the form of CO_2 from the air, transforming it into organic matter and thereby transferring it into the soil, which boosts soil productivity and resilience to harsh climate conditions. Creating conditions with plants, soil and fertilizer to encourage this process is a method for mitigating GHG concentration in the atmosphere, which is known as carbon sequestration.

Nitrogen is a ubiquitous element present in soil, as well as in gaseous form as N_2O in the atmosphere. N_2O has a global warming potential almost 300 times that of CO_2. It has many sources, but in soil it is naturally produced when microorganisms and bacteria transform nitrogen from ammonium — a component of fertilizers and manure — into nitrates, which are more easily taken up by plants. The processes of transforming ammonium and nitrate are called nitrification and denitrification. By carefully optimizing the use of certain fertilizers and manure in agriculture, N_2O releases can be minimized while still allowing plants to thrive.