Bob Ratliff

Freeze-dried wheatgrass is used in the project's NMR analyses.

Ken Jones

University of Toronto graduate student Neil Meikhan, left, with Andre and Myrna Simpson.

The Simpsons' NMR center at UTSC is the first of its kind in the world dedicated to research in environmental chemistry. The lab's state-of-the-art equipment is specially designed for separating and analyzing complex mixtures.

High-Tech Research Gets Nitty-Gritty on Dirt

By Bob Ratliff

For most people dirt is just dirt. Farmers, however, know all too well that soil properties can mean the difference between success and failure of a crop.

Soil scientists also don't take dirt for granted. That's especially true of a group of Mississippi State and Canadian researchers changing the way natural organic matter in soil is studied.

MAFES soil scientist Billy Kingery and the husband-and-wife team of Myrna and Andre Simpson at the University of Toronto at Scarborough (UTSC) are leading a project that includes the use of nuclear magnetic resonance, or NMR, technology to study organic matter in soil ecosystems.

The research is funded in part by a MAFES Special Research Initiative. The Mississippi Department of Environmental Quality, the National Estuarine Research Reserve System and the Canadian Foundation for Climate and Atmospheric Sciences also provide support for the MSU/Canadian collaboration.

"With this project, we're using NMR to take an unprecedented look at the biochemistry and structures of plant material and natural organic matter," Kingery said. "From an agricultural standpoint, the study will provide information about the effects of herbicides, pesticides, and nutrients on plant growth."

The NMR spectrometer is similar to magnetic resonance imaging (MRI) equipment found in hospitals. Both rely on advanced technology that uses magnetic fields and radio waves to acquire detailed information.

"MRI looks at the human body," said Andre. "NMR works on a much smaller scale, looking at compounds found in organic matter. By placing samples in a tube and inserting them into the NMR, you can look at soil, leaves, air particles, really anything found in nature. It basically produces a molecular map."

The collaboration between the Canadian researchers and Mississippi State scientists focuses on pollutants deposited in the soil by various means.

"NMR has been used for decades for routine analysis of small molecules," Myrna said. "But it's rarely used to analyze the components of matter from various sources within the environment, such as soil, air and/or water."

The Simpsons' NMR center at UTSC is the first of its kind in the world dedicated to research in environmental chemistry. The lab's state-of-the-art equipment is specially designed for separating and analyzing complex mixtures.

In addition to Kingery, MSU personnel working on the project include civil engineering professor David Huddleston, postdoctoral researcher Brian Kelleher, graduate assistant Rachel Stout, and research technician Grady Jackson. Kelleher, Stout and Jackson are all in the Department of Plant and Soil Sciences.

The MSU/Canadian connection began in 1997 when Andre, then with the Chemistry Department at the University of Birmingham in England, collaborated on Mississippi State's experimentation with NMR for the study of natural organic matter in soils. He then spent a year advancing the initial studies as a postdoctoral scientist at the Starkville campus.

MSU's role in the research includes the growth and isotopic labeling of plants. A special growth chamber on the North Farm is used to grow the plants. In the chamber, the input of carbon dioxide to the plants can be regulated and nutrients can be added in accordance with the research goals and objectives.

"The plants are grown with carbon and nitrogen enriched with isotopes, or labels, that allow a more in-depth study of the plant make-up and biochemistry, as well as the molecular structures of natural organic matter derived from plant tissue decomposition," Kingery said. "Once labeled and freeze dried, wheatgrass produced in the North Farm chamber is 100,000 times more sensitive to specific NMR analyses than normal grass."

In addition to tracing what happens to crop inputs such as fertilizer and pesticides, the NMR process also is used to track carbon. The release of carbon in the form of CO^2 can influence climate.

"A significant portion of the earth's carbon is tied up in the soil, but it's unclear how long it takes for it to move into a different part of the carbon cycle," Andre said. "The process we're working with will help improve accounting of global carbon."

The carbon part of the study, Kingery said, may lead to a better understanding of how agricultural practices can be used to help hold carbon in the soil and the potential impact that can have on climate change.

"The results of this study and their potential for management of crop inputs and residue can be used to generate significant economic benefits for producers and also to create new tools for environmental protection," he said.

That potential makes dirt more than just dirt.

Bob Ratliff

University of Toronto scientist Andre Simpson, left, and MAFES soil scientist Billy Kingery.