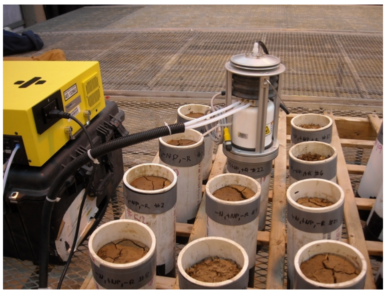
Global issues such as climate change and energy security have driven rapid growth in renewable energy production - wind, solar, tidal, geothermal, hydro, biofuels etc. However, logically, each of these methods should deliver a net benefit in terms of greenhouse gas (GHG) reduction, so researchers in the United States have employed portable FTIR analysers to study the GHG emissions of biomass production processes. “It would be futile to manufacture biofuels in an attempt to mitigate climate change if the production process created more GHGs than were saved by using biofuels instead of fossil fuels,” says Dr.Joe Storlien from the Texas A&M University Department of Soil & Crop Sciences.



During the production of bioenergy crops, GHGs such as carbon dioxide, nitrous oxide and methane are lost from the soil through both natural and managed biogeochemical processes, and the researchers were able to measure these gases by installing collars within field study plots. Chambers of known volume were then fixed to the collars,and tubingconnected the chambers to aGasmet DX4030multiparameter FTIR analyser which measured increases in gas concentrations inside the chambers’ headspaces over time (GHG diffusingout of the soil).

The research team included: Drs. Joseph Storlien, Frank Hons, Jason Wight and James Heilman.

Background

The research formed part of a major initiative to identify suitable crops for biofuel production; particularly cellulosic crops which produce large yields and can be harvested and converted into advanced biofuels, such as cellulosic biofuel. Bioenergy sorghum is one such feedstock which has shown great promise as a future bioenergy crop; it is not utilised as a food source, is an annual crop (single year land commitment for production), can produce large yields (more than 10-15drytons per acre) which minimises land use requirements, has suitable biomass chemical compositional properties for fuel conversion, and requires relatively fewer inputs than many other bioenergy crops.

In the United States. biofuels must meet certain GHG reduction targets according to a federal mandate (Energy Independence and Security Act of 2007). In accordance with the mandate, cellulosic biofuels need to meet a 60% reduction in lifecycle GHG emissions in comparison with a petroleum standard.

Biofuel GHG research project - Texas A&M Agrilife Research Farm

Agronomic management practices (fertilization, crop rotation, organic residue management, etc.) can affect the amount and type of GHG emissions that are lost from the soil. The researchers therefore studied the management production scenarios that are employed to produce bioenergy crops in order to determine which scenarios provide the greatest sustainable long-term yields and simultaneously minimise GHG emissions.The study analysed both direct GHG emissions (arising from the field trial itself) and indirect GHG emissions (arising from the production and delivery of trial inputs - such as tillage, planting, fertilization, irrigation etc.), soil carbon sequestration to a 3-foot depth, and theoretical biofuel yield from eight different sorghum production scenarios.

The highest CO_2 and N_2O fluxes were observed during the growing season and usually followed nitrogen fertilization and/or precipitation/irrigation events. However, crop rotation did not significantly influence cumulative CO_2 or N_2O emissions, whereas the retention of half of the bioenergy sorghum biomass on the field as an organic supplement consistently increased CO_2 emissions.

Although residue return and nitrogen fertilization offered the least GHG emission reduction, the researchers have suggested that these may be necessary management practices to sustain both long-term economic yield and soil quality. Additional research is therefore required to evaluate optimal nitrogen and biomass residue application rates to minimise GHG emissions while sustaining long-term yields.

Summarising the conclusions that have been drawn so far Dr.Storlien said: “Unfertilized, monoculture sorghum with half the yield returned to the field to provide nutrients and organic matter had the greatest overall biofuel production efficiency based on net greenhouse gas emissions savings. However, crop rotation and fertilization would be recommended to minimise pest pressure and sustain long-term crop yield.”

FTIR Gas Analysis

In the early stages of the project, a gas detection technology with a more limited number of measurands was employed. However, following the acquisition of an FTIR (Fourier Transform InfraRed) analyser, it became possible to measure almost any parameter simultaneously. For example, ammonia was added to the list of measured compounds, which provided greater insight into the nitrogen cycle. The FTIR analyser that was chosen for this work was a portable battery-powered instrument; the DX4030, manufactured and supplied by Gasmet Technologies.

Describing the gas monitoring methodology, Dr.Storlien says: “We use the data from the DX4030 to measure the ‘flux’ of GHGs from the soil over time (plotting rate of change over time). We measure fluxes of GHGs in the field approximately weekly during the growing season and then at a reduced rate (every 2-3 weeks) during the fallow season. At the end of each year, we determine the individual and cumulative mass of GHGs lost from each plot.

“All individual GHG measurementsare converted to CO2-equivalents (e.g. N2O is multiplied by 298;its global warming potential compared to CO2), so that we are performing an equal evaluation of the total global warming potential for each field plot. We are then able to divide the crop yield data by the total GHG emissions (direct + indirect) in order to compare and evaluate the different production scenarios.

“In addition to the GHG/sustainability measure, the emissions data from the FTIR analyser also helps us to better understand the carbon and nitrogen cycles within the cropping systems.”

The Gasmet DX4030 employs an FTIR spectrometer to obtain infrared spectra from each gas sample by first collecting an ‘interferogram’ of the sample signal with an interferometer, which measures all infrared frequencies simultaneously to produce a spectrum from which qualitative and quantitative data are produced. Over a number of years, Gasmet has established a vast library of FTIR reference spectra. This means that users of the Gasmet FTIR analysers are able to specify those compounds that they wish to monitor, so that the instrument can be configured to provide simultaneous almost real-time readings. It is also possible to reanalyse produced spectra with the instrument’s PC based software (Calcmet) and thereby to identify unknown gases.

Other GHG research applications for FTIR

The flexibility of the DX4030 has been a major advantage to Dr.Storlien and his colleagues, and as a result, the instrument has also been employed on two other bioenergy-related projects, both of which utilised the FTIR to measure GHGs from soils in greenhouse experiments.

In a project involving algae-biofuel production (extracting lipids from aquaculture-farmed algae to produce liquid biofuels) researchers at Texas A&M University are looking at ways to utilise the leftover coproduct as organic fertiliser, because the dry algae coproductstill contains valuable nutrients.A part of the project involved a greenhouse experiment using PVC soil columns mixed with selected rates of the algae coproduct and wheat straw. In this application, the researchers utilised the DX4030 to evaluate how the addition of the coproduct influenced GHG emissions over time.

The DX4030 has also been utilised in a project to determine whether a commercial nitrification inhibitor (thought to reduce N2O emissions) could reduce GHG emissions in bioenergy sorghum crops. A greenhouse study (similar to the algae study) was used to test the nitrification inhibitor with soils amended with nitrogen fertilizer and sorghum residue.

The advantages offield-use instruments

With extensive field experience, Dr.Storlienbelieves that there are many advantages to be gained from portable battery powered instruments such as the DX4030.

The ability to monitor a range of compounds simultaneously is a major advantage, and one that appeals to a broad section of the research community.Access to live readings provides an opportunity to check that the monitoring is proceeding correctly and in the case of the DX4030 data can be viewed and logged on a PDA that connects wirelessly with the instrument via Bluetooth, and/or the instrumentcan be connected to a laptop computer.

Ideally, field-use instruments should be small and lightweight. However, while the DX4030 is almost 12Kg, the researchers in Texas built a wheeled cart to further improve transportation in the field. The greenhouse studies also showcased how the instrument could be left on a benchtop and connected to mains power for laboratory studies. In Texas only one person was necessary for gas monitoring where two people had previously been necessary.

In-field/instant results can mean that there are no concerns about collecting samples and transportation to a laboratory for further analysis.The Texas researchers, for example, obtained a new measurement every 20 seconds which halved the deployment time and saved substantial costs.

Sensitivity and accuracy are obviously important in gas studies, and these have to be weighed against instrument cost. The Texas workers found that the move to FTIR was advantageous in terms of both performance and cost.

The deployment of a portable FTIR instrument has clearly been a significantbenefit to the project team in Texas. Summarising, Dr.Storlien says: “Due to the versatility of the Gasmet FTIR, we believe there will be numerous projects in the future that will benefit from this technology. I really think that mobile-FTIR could become very popular with researchers, because it does a great job measuring GHGs and helps us understand how humans impact the drivers of global climate change, which is extremely important and a booming area of research.”