University of New England

NSW Government | Industry & Investment

# Innovation

News from the Primary Industries Innovation Centre

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The Primary Industries Innovation Centre is a joint venture partnership between the University of New England and Industry & Investment NSW and incorporates the National Centre for Rural Greenhouse Gas Research

# From the Director

Another exciting year for PIIC is rapidly drawing to a close. The highlight of the year was the launch of the National Centre for Rural Greenhouse Gas Research and the appointment of Professor Annette Cowie as its Director. Annette has taken over the soil carbon research program and we now have four PhD students working in this area. See "soil carbon under the microscope" on page 5. The interest in biochar has continued to grow apace during the year with the success of the First Asia Pacific Biochar Conference, which was held on the Gold Coast in May. Annette and Industry & Investment colleagues played a major role in organising a highly successful conference.

Climate change adaptation research is an area that PIIC is moving into. Dr De Li Liu, Fiona Scott and Bruce Haigh and I are working on a pilot modelling exercise to answer the question: "can management adaptations such as alternative crop species and varieties or changed planting windows offset the negative impacts of climate variability and climate change?" We are doing crop simulations using APSIM to predict crop yield outcomes for different locations and climate change scenarios in North-West NSW with a focus on summer crops. We plan to couple the simulated climate change scenarios with whole-farm economic optimisation to analyse options for transition from existing to new farming systems in the face of climate change.

Development of functional foods and food-based nutriceuticals that reduce the risk of lifestyle diseases is a priority in I&I NSW's "Research for Action" strategy for productivity and food security. A PIIC PhD scholarship holder, Nisha Avarind, has made a start by investigating additives to reduce the glycemic index of pasta. There are significant opportunities to explore regional food processing waste streams for bi-products that have functional food or neutraceutical value. PIIC is sponsoring a "Functional Food Forum" for 12 regional food processors at the Tamworth Agricultural Institute on 4 December to explore collaborative research opportunities with regional industries.

*Bob Martin pictured in a PIIC feature in The Australian Financial Review in August titled "Research, Innovation and Commercialisation: Tackling big problems in rural NSW" (Photo by Glen McCurtayne).*

# Farmers Engaged in whole-farm Greenhouse Gas Audits

Southern New England Landcare (SNEL) and Lower Apsley River Landcare propose to set up a project to engage farmers in whole-farm greenhouse gas audits. The objective is to develop a process to engage farmers in whole-farm climate change issues including examination of the full greenhouse gas impacts for different enterprise combinations and management options.

SNEL approached PIIC/NCRGGR to ensure that the appropriate scientific methodology is used. SNEL has an interest in carbon emissions, carbon sequestration potential at whole-farm scale. They are concerned that farmers are seen as the 'bad guys' and are looking for more information on whole farm carbon audits. SNEL and PIIC/NCRGGR are funding a pilot study on five grazing properties.

SNEL will appoint a coordinator for the project to convene a project team. Once the coordinator has been appointed, the five farmers will participate in a workshop - hopefully in October. Farmers would need to fill out data forms before the workshop. The workshop will:

- establish what farmers want to know about carbon on their farm;
- explain the National Carbon Accounting Scheme and what's currently in and out of the scheme;
- include a hands-on FarmGAS calculator exercise – farmers enter their own data (need to bring this to the day);
- discuss options for development of the 'ideal' whole-farm greenhouse calculator.

The FarmGAS calculator was developed by I&I NSW's Pat Madden with funding from the Department of Agriculture, Forestry & Fisheries (DAFF) under the national climate change action plan and administered under the Australian Farm Institute. The calculator is designed to enable farmers to calculate the farm gross margin and greenhouse emission implications of changing their farm practices or enterprises.

The project will look at how the FarmGAS calculator could be adapted - starting with a Kyoto compliant version and then adding in soil carbon etc as extra macros. Data for livestock are based on ABS categories, state and seasons and more regionally-specific data are required. More detail is also needed for seasonal changes in liveweight, liveweight gain, quality of feed and emission factors.

# Biochar and bioenergy technology solutions

*The BEST Energies pilot pyrolysis plant at Somersby.*

Eureka Prize finalist in 2009, Adriana Downie Chief Technology Officer, BEST Energies Australia presented a public lecture on biochar and bioenergy solutions at UNE on 24th July.

Australian developed biochar technology is leading the world in demonstrating carbon negative (sucking CO2 from the atmosphere) renewable energy production. The technology recycles waste biomass such as animal manures and municipal greenwaste to produce renewable electricity (displacing fossil fuels) and a very stable form of carbon called biochar which can be sequestered beneficially over the long-term in soils (natural, low-risk sinks).

Technology developers BEST Energies have a fully operational slow pyrolysis demonstration facility at Somersby, NSW. The technology has been proven to be robust to a large variety of waste organic feedstocks, to be a net exporter of energy and to have a negative carbon balance, sequestering more carbon than it emits at a ratio of 4 to 1. BEST have been working closely with NSW Department of Primary Industries to verify their AgricharTM biochars potential to both sequester carbon and improve productivity in a range of Agricultural applications.

Biochar offers many advantages for environmental management as it combines solutions for biomass waste management and resources recovery, with the production of renewable 'green' energy, the increased sustainability of agriculture through biochar application, increased energy efficiency in industry, carbon sequestration and rural development. Several collaborative feasibility studies have been conducted to assess the business case for the commercial role out of the technology for the benefit of Australian industry and farmers. The economic drivers are well understood and the commercialisation pathway and near term applications will be discussed

Adriana is a leading figure in the promotion and development of biochar and was recently selected as one of the Next 100 Emerging Leaders by The Australian for her work in this area. Adriana has been operating as the chief technology officer for BEST Energies Australia for the past four years. She holds bachelor degrees in both Chemical Engineering and Science from the University of Queensland. She is also currently undertaking the final stages of a PhD program at the University of New South Wales on the pyrolysis of biomass for biochar and bioenergy for which she was selected as a finalist for a Eureka science prize.

# Woody plant regeneration in grazing landscapes


*Scott (left) has received a PIIC honours bursary in support of this important project. Scott is supervised by PIIC research fellow Dr. Melinda McHenry (right)*

Scott Keelan completed his Bachelor of Science undergraduate degree in 2005 as a mature aged student. From here he gained fulltime employment with the NSW Rural Fire Service as a Fire Prevention Officer in the southern riverina area of NSW. Some of the units of study which Scott enjoyed while at UNE focused on fire ecology and plant responses to disturbance. He says he can apply some of his skills and interests in his current position while determining long term bush fire management plans and working closely with government land management agencies.

The current partnership with PIIC is providing an opportunity for further studies relevant to the rural sector. This has led to the development of an Honours project entitled "Woody plant regeneration in grazing landscapes in the NSW wheat sheep belt: climatic contrasts and carbon futures".

This project will use a number of different techniques in an attempt to identify the precise combination of factors that have lead to the contrasting regeneration patterns of woody plants in north and south NSW. Whilst woody plant regeneration occurs en masse in northern and central NSW and is often a nuisance for landholders, the same tree species are now in decline in southern NSW, with some trees and communities now listed as endangered. Given that trees often represent the most substantial contribution to site total carbon stores, identifying processes that govern tree regeneration in rural landscapes is now especially important. This project will quantify site carbon stores across grazing landscapes in the wheat sheep belt which will assist in landscape planning and future participation in emissions trading schemes.

# Primary Industries and Resources Committee visit the Liverpool Plains

The Australian Parliamentary Standing Committee on Primary Industries and Resources is currently conducting an inquiry into the role of government in assisting Australian farmers to adapt to the impacts of climate change. Three members of the committee visited three farms on the Liverpool Plains.

Tony Windsor Member for New England and member of the committee invited Bob Martin to accompany the on a tour of the Liverpool Plains on 2nd July. The committee was represented by Dick Adams (chair) and Sid Sidebottom. The invitation to join the tour was extended to NSW DPI technical experts John Kneipp (technical specialist northern farming systems), Loretta Serafin (District Agronomist Tamworth) and Bill Manning (District Agronomist Gunnedah).

David Wallis "Manuka" Quirindi and Cam McKellar "Inverary" Spring Ridge strongly promoted biological farming and claimed to have increased their soil organic matter from <2% to >3%. Biological farming involves ploughing and there was a lot of discussion about the sustainability of this with regard to soil erosion and

*Tony Windsor (left), Dick Adams (centre) and Sid Sidebottom (right), members of the Federal Government enquiry on farmers' adaptation to climate change, at the property of Cam McKellar "Inverary" Spring Ridge.*

destruction of soil structure. Andrew Pursehouse "Breeza Station" Breeza stood by his no-till system with long-term adoption of no-tillage and sustainable rotation of cereals with grain legumes such as faba beans. The practices of biological farming and no-tillage need to be compared for their capacity to store carbon, increase soil biological activity and adapt to climate change.

# Mango and macadamia thesis submitted

PIIC PhD scholarship holder, John Wilkie recently submitted his thesis "Aspects of flowering and flushing of mango and macadamia". John's supervisors were Prof Margaret Sedgley (UNE) and Dr Trevor Olesen (I&I NSW). John is now a researcher at the Department of Primary Industries and Fisheries (DPI&F) Applethorpe Research Station.

John's research was prompted by grower interest in canopy management options that promote consistent production. For mango, it is well established that poor production is due to erratic flowering and sometimes fruit set. John investigated the effect of the time of pruning on subsequent vegetative growth, flowering and yield because flowering is dependent on mature vegetative flushes during the winter months.

For macadamia, flowering is also dependent on mature vegetative flushes during the winter months, so John developed a model of the dependence of the rate of flush development on the environment. The model has been used to predict the effect of pruning strategies on flowering and yield. Trials have also been undertaken to determine the effect of pruning time on vegetative flush development, flowering and yield.

The relationship between flower number and yield was previously unknown for macadamia, so canopy management strategies that increased flowering may not necessarily increase yield. These relationships have been determined for two varieties, along with suppressive effects of high flower and crop load on flowering and cropping in the following year. Interactions between stem characteristics and the likelihood of flowering have also been determined.

# International Symposium on Soil Organic Matter Dynamics: Land use, Management and Climate Change

Drs. Subhadip Ghosh and Brian Wilson attended the second "International Symposium on Soil Organic Matter Dynamics: Land use, Management and Climate Change" which was held at Colorado Springs, USA from July 6-9, 2009.

The aim of the symposium was to present the latest research on soil organic matter (SOM) across the globe and highlight future research directions. Nearly 300 soil scientists from 33 countries gathered at the conference under the theme "Land Use, Management and Global Change". Conference host Professor Keith Paustian of Colorado State University inaugurated the conference emphasizing that global SOM stocks are estimated at 3 trillion tons. Dr. Ghosh and Dr. Wilson presented their findings on the session on 'SOM - global & regional perspectives'. Dr. Wilson presented his paper entitled "Opportunities and barriers for the estimation and prediction of soil carbon at State and catchment scales in New South Wales, Australia" and Dr. Ghosh's oral presentation was on "Impact of land use variation on soil C change in different agricultural soils in NW New South Wales, Australia.

In an era where rising concentrations of atmospheric carbon are threatening global climate function, ecosystem stability and agricultural productivity, the sheer size of the soil carbon pool makes it imperative that we learn more about the pool's dynamics. Highlights from the remarks of the event's leading presenters illustrate the profound ways that soil dynamics and the variations in soil carbon storage capacity might impact individuals, communities and nations.

Professor Abad Chabbi of France pointed out that the clear challenges addressed in the last conference in 2007 still persist today, including:

- The extent and role anthropogenic forcing.
- The feedbacks between vegetation and SOM.
- Interactions between climate change, SOM and biodiversity.
- SOM generated greenhouse gases.
- Soil quality and SOM.

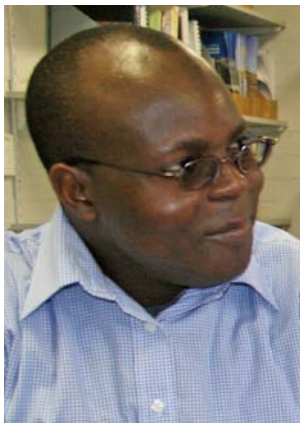
The work presented at the conference illustrates the national and international significance of soil carbon storage. It highlighted key research needs with respect to SOM storage and management that are being addressed through research projects being undertaken at UNE.

# Soil carbon under the microscope

A workshop was held at UNE on 24th July to assist with the integration of four new soil carbon PhD programs into the PIIC 'Land the carbon bank' soil carbon research program. These projects will complement research funded by the national soil carbon research program to improve soil management and determine the potential of sequestration of carbon in a variety of soil types, locations and under differing management practices across NSW. Preparation for the workshop was a valuable exercise for the students and they are now ahead of schedule in defining their research objectives and methodology.

Christine Walela will study soil organic carbon storage, quality, and depth distribution under continuous cropping, perennial long term pasture and remnant vegetation on a range of soil types. Christine's study aims to:

- Evaluate the relative amounts of soil carbon stored under the land-soil type combinations across a range of sites;
- Determine soil carbon pool sizes, C mineralization rates and turnover at depth;
- Evaluate quality and decomposition of above-ground litter within the systems;
- Characterise total soil organic matter quality using 13C CP/MAS NMR spectroscopy;
- Model soil organic carbon storage under the three land use systems.



Giregon Olupot will attempt to determine the fine root contributions to sequestration of soil organic carbon below ground. Mounting evidence indicates that plant roots play a more important role than shoots in contributing to SOC through continuous supply of dissolved organic carbon (DOC) and stabilisation of soil structure. It is expected that the data will be helpful for calibrating Australia's National Carbon Accounting Model (FullCAM). The study may also provide clues as to what adjustments to the existing land uses may be needed to increase their potential to sequester root-derived carbon and duration of storage of the sequestered carbon.

Giregon's objectives are to:

- Evaluate fine root morphological properties and rooting characteristics, including fine root biomass, length and fine root diameter; rooting depth and distribution of fine root-size classes with depth;
- Laboratory incubation experiments to determine the mineralisation rates of fine roots and potential contribution to soil organic carbon. The nuclear magnetic resonance (NMR) technique is proposed to determine the chemical quality of fine roots and how it may help explain the decomposition characteristics;
- Determine the stability of macro-aggregates to wetting and erosion forces in relation to the location of fine root-derived SOC within the soil aggregates.
- Assess the effect of legume cereal crop rotations on fine root morphology and vertical distribution using X-ray computer assisted micro-tomography. The rate of deposition of recent SOC from fine roots into the aggregates will be assessed by analysing peeled layers of macro-aggregates.

Fazle Rabbi will study stabilisation of soil organic carbon in soil micro-aggregates under different organic inputs, tillage and cropping patterns.

Soil organic matter is one of the major pools of the global carbon cycle. Soil micro-aggregates (<250 µm) have unique capacity to protect organic matter from decomposition. The overall objective of the research is to evaluate the effects of organic inputs and agricultural land use under conventional and no-tillage on the amount and nature of carbon associated with soil micro-aggregates in Vertosol, Chromosol and Ferrosol soils. The aggregate stability and mineralization rate of organic carbon associated with aggregate size fractions will be determined.

The dispersion ratio and pore geometry of soil aggregates will be determined to relate these parameters with the amount of organic matter in micro-aggregates. Pore geometry will be determined by computerized micro-tomography. The light fraction, particulate and stable organic matter associated with each aggregate size class especially with micro-aggregate will be determined by density fractionation and chemical methods. The

chemical nature of micro-aggregate organic carbon will be determined by solid state 13C NMR. A theoretical study based on linear regression modelling will be conducted to evaluate the capacity of soil to protect organic matter.

Nimai Senapati will attempt to simulate soil organic carbon dynamics under different land use and crop management practices. His first objective is to determine carbon sequestration potential under different land use and management systems. This will involve (a) identification of potential land use and management systems which can build up the SOC stock and (b) determination of SOC pools under different land use and management systems. Estimates are required for modeling of the resilience of SOC stocks in SOC pools under different land use and management strategies.

Nimai's second objective is to identify the best suited model to apply to various land use and management systems in the study area. He will attempt to validate the CENTURY, DNDC and FullCAM models under different land use and management systems. Calibration of the best suited model in the study area will remove the uncertainty for simulating SOC stocks in the region.

# Uralla pilot pyrolysis project seeks expert advice

In July, Adriana Downie Chief Technology Officer, BEST Energies Australia was invited by the Uralla Climate Forum to present details of cost and operation expenses of a 3MW pyrolysis plant. The Forum is conducting a preliminary feasibility study to examine the process of utilising locally available biomass material for the production of electricity and biochar via a pilot slow pyrolysis plant in Uralla. Biomass streams being considered are regional municipal wastes, forest thinning and thinning from 'engineered woodlands'.

The NSW Government recently initiated a number of Community Climate Consensus Forums targeting selected local councils, seeking input to the NSW Climate Summit held in February 2009. The summit formulated recommendations to the Minister for Climate Change and the Environment, Minister Carmel Tebbutt. Amongst the recommendations emanating from the Uralla Climate Forum was support for local renewable energy production.

The Climate Consensus Project participants in Uralla have since held several meetings and a significant body of information has been examined addressing the issues involved in establishing a pilot slow pyrolysis electricity generation plant in the Southern New England Tablelands, particularly in Uralla. A number of potential stakeholders have been involved in discussions about this project. The process has now reached the stage of requiring a preliminary report on the analysis of a pilot slow pyrolysis electricity generation project in Uralla.

Adriana advised the Uralla Forum that establishing a pyrolysis plant will be a challenge as there are many groups with similar concepts. There has been a lot of interest in pyrolysis for dealing with urban greenwaste to reduce the costs involved in disposal. Biomass

*Uralla Climate Forum's Richard Croft and Adriana Downie discuss the potential for 'engineered woodlands' to provide biomass for a proposed pyrolysis plant at Uralla.*

feedstocks in rural areas usually have other uses and are likely to come at a cost. For example the cost to deliver forestry residues to Uralla is estimated at $80 per wet tonne or $160 per dry tonne. At these prices, a pyrolysis plant would run at a loss because of the low cost of electricity in Australia and the absence of carbon credits for biochar at present.

However, Adriana said that projects like the Uralla pyrolysis plant are coming of age and feasibility studies should be done. The Federal government has committed to reduce Australia's carbon pollution to 25 per cent below 2000 levels by 2020. It is expected that the land sector might be included in the Carbon Pollution Reduction Scheme (CPRS) in 2012. The Department of Climate Change has indicated that soil carbon initiatives such as biochar might be included in the agreement if scientifically demonstrated.

# Post-Graduate Research Opportunities

The greatest challenges facing humanity in the next 50 years are the adequate provision of food and fresh water, coping with climate change, and maintenance of ecosystem services. Australia must make increasingly effective use of scarce water resources, reverse losses from soil including nutrients and carbon, and regenerate degraded land. We are currently offering post-graduate opportunities in:

- Climate change adaptation (Bob Martin, +61 2 6773 2869, bob.martin@une.edu.au)
- Climate change mitigation (Annette Cowie, +61 2 6773 3924, annette.cowie@une.edu.au)

## Assessing the Impacts of Biochar on Greenhouse Gas Emissions from Soil

Biochar potentially has a major role in climate change mitigation and in enhancing sustainability of Australian agriculture. There is growing evidence that biochar can enhance plant growth, improve nutrient and water use efficiency, enhance soil properties, sequester carbon for hundreds to thousands of years. New research indicates that some biochars can reduce greenhouse gas emissions from soil.

A PhD candidate is sought for a project to assess the impacts of biochar on greenhouse gas emissions from soil. The candidate will be primarily located at Industry & Investment NSW's Wollongbar Primary Industries Institute near Lismore but will also be required to spend time at the UNE campus in Armidale. The PhD project will be part of a National project administered through the CSIRO and funded by the Australian Department of Agriculture, Fisheries & Forestry. The student will be expected to have sound chemistry and soil/environmental science background. There will be opportunities to work with state-of-art analytical equipment. A PhD stipend to the value of $25,000pa will be available to the successful candidate.

PhD eligibility criteria can be obtained from: http://www.une.edu.au/courses/2009/courses/PHD. Informal inquiries can be emailed to Dr Lukas Van Zwieten (lukas.van.zwieten@industry.nsw.gov.au) or phone +61 2 6626 1126.

## Development and Characterisation of Pasta as a Functional Food

A PhD candidate is sought for a project on the development and characterisation of pasta as a functional food, a project that is a collaboration between UNE, Industry & Investment NSW and the Australian Nuclear Science and Technology Organisation. A top-up of $3000 per annum will be available to the APA. The candidate will investigate: effect of various combinations of fibres on the benefits to pasta including structure-function relationships in modified pastas and use of enzymes in selected functional pastas. PhD eligibility criteria can be obtained from: http://www.une.edu.au/courses/2009/courses/PHD.

Informal inquiries can be emailed to Dr. Chris Fellows or phone +61 2 6773 2470. Scholarships are competitively available through the UNE's postgraduate program. Application forms can be obtained from: http://www.une.edu.au/research-services/forms/domesticappform.doc.

## CONTACT US

Primary Industries Innovation Centre
University of New England, Armidale NSW 2351
Ph: 02 6773 2745 • Fax: 02 6773 3238
www.une.edu.au/piic