Australian Government
Cotton Research and Development Corporation

TRAVEL & CONFERENCE REPORT

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **CSP1202**

Project Title: Travel: European Geosciences Union (EGU) Assembly, Vienna, Austria - April 2012

Project Commencement Date: 20/04/2012 **Project Completion Date:** 28/04/2012

Research Program: Human capacity

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Part 3 – Travel Report

(Maximum two pages)

1. **A brief description of the purpose of the travel**.
   Attend and present a paper on long-term cotton experiments and changes in soil organic carbon in Australian cotton soils at the European Geosciences Union (EGU) Assembly, Vienna, Austria

2. **What were the:**
   1. **major findings and outcomes**

The EGU Assembly was held in the Austria Centre Vienna.
The total number of delegates was 11,000 of which 950 participated in the Soil Systems Sciences (SSS) Division.

This was the first time that cotton, as a specific crop, has been included as part of the SSS. The topic specifically addressed in SSS11.8 was "Cotton production practices impacts soil quality".
Six oral papers were presented and 11 poster papers were displayed for this session.

Oral papers presented Wed 25 April:

K Hake: Conservation tillage impacts on soil quality.
Blaise DeSouza & JV Singh: Cotton production practices change soil properties.
S Bergonzoli & P Servadio: Agricultural wheeling and soil qualities mapping in climate change conditions.
P Ton: Cotton and climate change: Impacts and options to mitigate and adapt.
M Braunack, N Hulugalle & I Rochester: Long-term rotation studies and the effect on soil organic carbon in cotton soils.
J Landers & P de Freitas: Zero tillage cotton systems and soil quality.

K Hake: stated that in the USA no-till promoted soil carbon and that no-till was being driven by round-up ready crops (mainly corn & soy), however this has resulted in herbicide resistance & increasing problem weeds. There was a move back to tillage for weed control and increasingly cover crops were being utilised to compete with weeds.

DeSouzza: stated that cotton production in India was slowing due to frequent & intensive tillage leading to soil loss by erosion & a loss in soil carbon. Also, inter-row cultivation pruned roots reducing productivity. Conservation tillage is being more widely adopted by Indian growers. When comparing conventional tillage with reduced tillage (included one cultivation for weed control) and reduced tillage with no soil disturbance; nutrient stratification of phosphorus, nitrate nitrogen and soil organic carbon (P, NO_3 and SOC) was occurring under reduced tillage, and fewer weeds occurred under reduced tillage compared with conventional. This was due to the incorporation of mulch which was sprayed out before re-planting cotton, which also resulted in lower bulk densities and more profile soil water.

Servadio: reported an increase in soil compaction due to increasing weight and number of equipment passes as indicated by increasing soil strength and shear

strength of the soil. They compared trafficked and non-trafficked areas under a tractor with high flotation tyres and a spray rig on narrow tyres. The level of compaction was similar under both, although the spray rig had greater sinkage.

Ton: reported on a life cycle analysis of the carbon footprint of world cotton. One problem is the inconsistencies in expressing this due to the fact that cotton is grown in a range of temperature environments, under varying degrees of water availability and pest & disease pressure. One short coming identified was a general lack of soil carbon data for the cotton industry. The full report is available from www.intracen.org

Braunack etal: Presented results on changes in SOC in the long-term experiments being conducted at ACRI in fields C1, D1 and F6. SOC decreased with depth, with the exception of rotations that had standing or incorporated stubble, however there was no one rotation that stood out from the others. Differences between the experiments at ACRI reflected the fact that two had subsoil constraint while the third did not. Also, the starting level in SOC differed between the three experiments and this is reflected in the rate of change in SOC levels in the 0-30 cm depth over time. Including tillage resulted in a decline in SOC, while rotations increased SOC over time.

Freitas: compared three systems for cotton in Brazil, conventional tillage (CT), conservation (CA)/zero till (ZT) & semi-direct (CT for the first cotton crop & ZT for the second cotton crop). Growers use a ley farming system with controlled traffic farming (CTF), planting on beds with equipment on high flotation tyres. One issue is soil nutrient management under ZT. Brachiaria is used as a green manure to improve soil conditions & to maintain soil cover. It is necessary to maintain a diverse rotation & avoid or minimise soil compaction. In the system pest control needs to be managed without tillage & roundup ready & liberty link spray-out survivors and volunteers need to be controlled.

This session being the inaugural one only attracted 20 people; nationalities included those from China, India and Kazakhstan. The most interest from the presentation was generated from the cotton harvesting images regarding the number of picks and equipment size.

2. **other highlights**

The sessions attended & a brief summary is provided below:

Mon 23 April:

Organic farming soils & energy balance:

This session covered a range of topics including the effect of slurry application on aggregate stability & carbon, nitrogen & phosphorus in grassland soil. Results showed that slurry application increases aggregate stability & stability decreased with tillage. Soil carbon increased with slurry and sporadic tillage had no long-term effect on grassland soils.

The energy balance concept is relevant to cotton in that it can be seen as a user of energy & a producer of energy. The concept looks at energy inputs v energy output. Energy productivity was defined as kg output/energy input, and organic systems were seen to have the greatest energy productivity compared with conventional systems.

Another component of energy balance was the carbon & energy balance for biofuels in the USA. What is the trade-off between producing biofuel compared with food crops? This work is being conducted to aid policy decisions for food & biofuel production.

Nanosized iron oxides in soils: agronomic, environmental & paleoenvironmental significance (including Phillipe Duchaufour medal lecture):

The medal lecture was on iron oxides & the role they play in identifying conditions during soil development.

Stabilisation of organic matter in soils, sediments and marine dissolved organic matter:

It was suggested that before soil organic matter (SOM) can be stored/sequestered that it must remain in/on the landscape. Work is being undertaken to examine the physical properties of SOM; such as density & porosity as these will affect movement of particulate SOM
Also when land is drained it affects plant diversity which will influence carbon & nitrogen distribution in the landscape; so carbon will be lower down the slope & at depth on undrained land compared with drained land. Nitrogen follows the same pattern.

Soil microbial biomass is a significant source of SOM & there is a rapid turn-over in this fraction. Soil pollutants can have a significant effect on soil microbial biomass, through reduction of populations & microbial decontamination of the pollutants. Management plays a significant role in microbial biomass as does level of pollution in maintaining SOM quality & quantity.

Water movement into inland natural water storages was suggested to affect organic carbon dynamics with large amounts of carbon being stored in lake sediment.

Eco-engineering mitigations against natural hazards: Biological and geophysical contributions to sustainable bioengineering in a changing world:

An interesting design for a core sampler for wet muddy soils was illustrated for core sampling mudflats.

Strategies were illustrated for arresting gully erosion and erosion by boat wash in waterways. Salix tillers were planted across gullies to trap sediment while not completely impeding water flow and willow mats were used on the batters of water ways to absorb wash from boats.

Tue 24 April:

Temporal dynamics & effects of changes in land use on soil properties & processes:

The effect of long-term tillage on P & different P pools (labile, stable & residual) was presented. P was influenced by organic matter (OM), Fe, Ca & clay content of the soil & the amount applied as fertiliser or removed in harvested grain. Mouldboard ploughing to 20 cm, ZT under sugar beet was compared by sampling 0-40 cm depth. There was no effect on residual P, except for the 5 cm depth, Al & Fe did not affect P availability & ZT increased P compared with mouldboard ploughing with some P being lost due to erosion from the sloping site.

Soil carbon stocks when land use was changed across the European Union (EU) were modelled. Soil organic matter is seen to indicate soil quality & soil function & important for ecosystem services. The general trend was for SOM to be decreasing across the EU. SOM decrease is attributed to agricultural production & forestry. When land is converted from grassland to arable SOM decreased, while conversion from arable to forestry increased SOM.

Farmer soil analyses are being used to determine land use change on SOM at the landscape scale. A large number of results available over a large period of time, however there are some difficulties in that there is poor geo-referencing of sample points, sampling depths vary & usually no bulk density (BD) values are available. To overcome the last problem pedotransfer functions are being developed for BD-SOM. Monte-Carlo risk analyses are undertaken to identify the uncertainty in the result.

The rehabilitation of a soil borrow pit was interesting, where little soil formation took place over a 40 yr. period. There were differences in vegetation succession which affected OM addition, soil strength & BD.

SPOT satellite images were used to identify changes in vegetation surrounding a lead smelter. Damaged vegetation could be identified using NDVI (Normalised Difference Vegetation Index), however this did not appear to be related to prevailing wind direction.

Gully erosion in an area where citrus plantations, bananas under plastic greenhouses & vegetables are grown was studied with a rainfall simulator. When the area was developed growers levelled the land to remove gullies & with subsequent rainfall the gullies reform.

Soil surface roughness & the effect on erosion were compared under CT (25 cm disturbance) & RT (12 cm disturbance) using soil strength, infiltration & water retention curves. X-ray microtomography was used to determine micro-structure differences between the systems. The saturated hydraulic conductivity (Ks) was greater for CT than RT. Surface roughness measures between CT & RT were inconsistent.

Land use & the effect on OM & soil physical properties in Argentina was compared under a wheat-corn-sunflower rotation with mouldboard or chisel ploughing or with NT. BD decreased from 2004 to 2007 & aggregate stability increased under NT

compared with the other treatments. NT had the lowest Ks and highest SOC. There was no yield difference between treatments for any crop grown. It was indicated that soil compaction may develop as an issue under the NT system.

Biochar for soil remediation & global warming mitigation:

The use of biochar has been suggested to mitigate climate change, for waste management, for energy production & soil improvement. However, are all feed-stocks suitable? Organic waste may be contaminated & be high in heavy metals. There is a need to know, what is the best biochar for different soil types & position in the landscape? (slope, valley etc.). Then there is application strategy; incorporation, broadcast, deep incorporation & so on. It has been found that biomass production has been greater than grain yield under biochar. Also, developing countries are creating charcoal as an energy source which needs to be considered in determining the sequestration benefit of biochar.
It was pointed out that all biochar does not look the same; it depends on the feed-stock, whether it is wood from different sources, crop residues and so on. The benefit of biochar has to exceed the cost of production. The resultant biochar depends on feed-stock, temperature at which it was created, technology used to manufacture it. Also, the intended use will determine the type of biochar required, so a system of quality control needs to be established.
The EU has conducted a life cycle analysis of biochar (Eurochar project available from a web site)
Laboratory studies have demonstrated that biochar supresses N_2O emissions & a few examples also indicate some field suppression. However, 50 t/ha of biochar supressed N_2O early in the season with little suppression thereafter compared with no biochar.
A pot experiment using labelled ^{13}C showed a varied & small response in soil microorganisms to biochar compared to environmental factors; soil disturbance had the greatest effect.
However, biochar in rice paddy increased SOC & caused little change in N content. Abundance of bacteria increased, fungi decreased & CO_2 emissions increased with bichar & this response varied with seasons.
Biochar degrades when exposed to wild fire (bushfires). Under laboratory conditions biochar is formed under arrange of temperatures. Biochar is very reactive, which puts into question the use of biochar for sequestration & climate change purposes.
In a pot study biochar had no effect on germination & restricted the early growth of wheat & had no effect on soil temperature. However, the type & application rate had an effect. The control was always wetter than biochar treatments as biochar enhances drainage. CO_2 flux increased on initial addition of biochar; once labile carbon had respired there was no effect on carbon flux, it was the same as the control.
The addition of biochar reduced uptake of Cd in both unpolluted & polluted paddy soils. There was no significant effect on rice yield however, there was less Cd in rice grains.
Biochar also remediated soils contaminated artificially with naphthalene, phenanthene & oestrogens in a pot experiment by influencing sorption & desorption properties of the soil.
Added biochar increased soil water in 0-6 cm depth compared to no biochar & it had no effect on soil temperature.

In pot experiments biochar had a significant effect on plant growth at very high (50 t/ha) application rates & no effect at low application rates (5 t/ha).

Wed 25 April:

Soil and irrigation sustainability practices:

Automatic controllers need to be developed for sprinkler systems to reduce labour input in reprogramming current systems as conditions change. Some issues highlighted were that water supply/demand needed to be matched, water needs to be allocated to minimise energy use & waste, sprinkler issues; wind drift, evaporative losses & field crops v high value row crops. It is suggested that crop models & irrigation models be used simultaneously to optimise irrigation.

A method was proposed to account for light rain, dew & fog in evapotranspiration based irrigation. It requires the development of curves indicating the percentage contribution of fog to time of drying of leaf surfaces.

The adaption of the FAO 56 spreadsheet to estimate evapotranspiration of olive orchards was improved by undertaking frequency domain reflectometry & time domain reflectometry measurements & sap flow measures to measure water use of the trees.

Irrigation scheduling of almonds in the USA now enhance by the development of an online irrigation management system, which simulates deficit irrigation. It is based on FAO 56 for application efficiency and FAO 33 for yield response. (www.oiso.bioe.orst)

The increase in hard surfaces (roads/buildings etc) in irrigation areas co-located near large populations results in pollution of surface water used for irrigation and an increased fragmentation of agricultural land.

Soil water tension (tensiometers/gypsum blocks) are being used for irrigation control however, it is difficult to determine reliable thresholds for deficit irrigation.

Fibre optics is being tested to measure profile soil water over extensive areas in real time. Steel & plastic encased fibre optic cable is buried at 25 cm over a distance of 1km, temperature is measured every 25 cm using a heat pulse along the cable. At present it is still in development.

Pervaporation is a technique being tested where a permeable membrane is buried in soil & membrane transport by sorption, diffusion & evaporation occur. The system is designed to use saline water, where saline water is pumped though the membrane & plant roots take up fresh water after it passes through the membrane with the salt water being stored in evaporation ponds. The system was tested under lab conditions. Vapour flow dominated water movement under the test conditions.

Thur 26 April:

Soil management as a determinant of microbial diversity and function:

Researchers are attempting to find fungal indicators of land use change at landscape scales. They have identified arbuscular mycorrhiza fungi (AMF) as a candidate as it is present in soils across the landscape. There are greater numbers of AMF in agricultural soil than industrial waste sites for example; forest soils were also included.
The question arises is AMF presence a function of soil properties or land use? AMF are ancient & widespread & occur as communities. They are affected by pH, soil texture, salinity, crop rotation, fertiliser regime & tillage. Landscale comparisons have not been made. A comparison was made after snow melt on grass & pasture, organic v conventional practices, intensity of land use (rotations), tillage systems on sites with similar histories across a gradient. Results showed that soil had the greatest effect on AMF communities, with management & geography having less of an effect. Microbial products being marketed as having a benefit on soils need to be treated with caution as problems may be introduced to an area where there was not one previously & they usually do not work.
Do plants foster microbial associations to compensate for limited resources? AMF are well adapted to grow in their 'local' soil. Plants perform best when grown in their 'home' soil with 'local' AMF, it is best to maintain the 'local' population of AMF. It is recommended not to add inoculants from elsewhere. This work was undertaken on native pastures which had never been cultivated & their ANF association in the USA.

Fri 27 April:

Digital soil mapping: novel approaches and sensing techniques to the prediction of key soil properties:

There was general consensus that large scale soil maps were expensive to produce, that economics prevented large scale soil surveys & associated laboratory analysis of samples. Strategies & techniques are being developed to produce maps more cost effectively. Electromagnetic induction (EMI), radiometrics (Gamma ray attenuation) & ground penetrating radar (GPR) are such techniques being utilised. Another issue is the selection of representative areas in the landscape for ground truthing.
There is some benefit of using geophysical techniques in predicting soil properties, however results were not good in sandy soils compared with clays. There is the need to calibrate EMI to local conditions. A relation was developed linking geophysical measures & soil function. Soil biomass was assessed in the same area as GPR & EMI measures with large differences in biomass able to be detected using a combined GPR/EMI map.
vis-NIR reflectance is another technique being tested for predicting top soil OC on a EU scale. Modelling using the LUCAS soil database was used to test whether this would be a suitable surrogate for measuring OC. It could not detect spatial or temporal changes in OC.
When comparing vis-NIR with a national database & using a measured reference site agreement between the two was only reached after the national database was 'spiked' with data from the measured reference site (The variability between

measured and predicted values was reduced when actual measurements from the reference site were included in the database).
Using vis-NIR on an airborne platform it was established that only bare soil measurements could map soil properties. Fe, clay, silt & CEC could be reasonably estimated, while silt, $CaCO_3$, pH &OC could not be confidently estimated.
Comparing field measured spectral data with satellite derived data to estimate topsoil SOC had an average error in prediction of 3-5 kg/ha SOC.
Gamma ray spectrometry is a rapid non-destructive sampling technique able to differentiate between K & Th soils. One needs to consider parent material if looking at the regional scale however, it is not important at the regional scale as the geology is similar at the smaller scale.

Teaching Soil Science or how to teach that dirt is fascinating:

Various strategies were presented; using human health as an analogy for soil health; online courses were being developed for students with no prior knowledge of science & were made interactive & used real world situations. One problem was not including basic maths to enable calculations of flow rates & many other essential parameters relevant to soil science.

Attendance at the EGU assembly enabled discussions with a range of cotton researchers from the USA, India and Brazil. The cotton industries in these countries face similar issues as the Australian industry; soil management to maintain productivity being the main one. Generally rotations & controlling in-field traffic are being widely adopted. Growers in the USA have similar concerns regarding round bale pickers on soil conditions to those in Australia. The main difference is that the majority of the cotton is dryland in the USA and to date few differences have been measured largely due to timing of the sampling.

3. Detail the persons and institutions visited, giving full title, position details, location, duration of visit and purpose of visit to these people/places. (NB:- Please provide full names of institutions, not just acronyms.)

4. a) Are there any potential areas worth following up as a result of the travel?
Discussions with Kater Hake explored opportunities for collaborative research with researchers in the USA on the impact of round bale pickers on soil compaction.

b) Any relevance or possible impact on the Australian Cotton Industry?

The planned sessions on subsoil compaction, the assessment of and possible amelioration, unfortunately were cancelled as insufficient interest was shown by participants. Notwithstanding this the researcher from the Brazilian cotton industry acknowledged that subsoil compaction was on the increase as larger equipment was being introduced by the industry.
The sessions on soil organic matter/carbon have relevance to the cotton industry in assessing carbon stocks on a landscape or industry scale.
With respect to biochar there are many issues to be resolved; specifically that biochar differs in properties depending on feedstock, the temperature at which it is formed and the technology used in its production. It was suggested that the effect in soil depends on soil type

Start of Project (normally 1st July)

(texture), application strategy (surface, shallow or deep incorporation) and rate of application. Also, biochar may not offer the sequestration opportunity as previously indicated due to the reactive nature of the product when exposed to heat (wild fires). The benefit of biochar has to exceed the cost of production and this has not been unequivocally demonstrated.

The study of arbuscular mycorhiza fungi may be warranted as an indicator of soil health and quality as they occur in communities over large areas and respond to changes in management. Generally the cotton industry is at the forefront in developing automated irrigation strategies to improve water use efficiency and productivity.

The effect of land use on soil organic carbon and changes in soil physical properties is important for the assessment of long-term rotation experiments and is relevant to the cotton industry. This may reflect on seedbed conditions generated after rotation crops and crop establishment. The prior history of a field may indicate ease of seedbed generation for a following cotton crop. This will be considered in planning of a project on the assessment of seedbed conditions to promote uniform crop establishment under thin biodegradable film.

5. How do you intend to share the knowledge you have gained with other people in the cotton industry?

An Australian Cottongrower article will be prepared from the presentation at the assembly.

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