Cotton Catchment Communities CRC

SUMMER SCHOLARSHIP - 2006/2007 SEASON

Project title

Cotton yield and soil carbon under continuous cotton, cotton-corn and cotton-wheat rotations

Aims and milestones

- To increase the soil organic carbon (SOC) using crop rotations in previously continuously cropped cotton fields
- Monitor SOC in four crop rotations – stable, labile and microbial fraction
- Analyse cotton growth and yield throughout the season for each rotation
- Compare the economics of each rotation

Staff:

Dr Nilantha Hulugalle, Senior Research Scientist,
NSW Department of Primary Industries and Cotton Catchment Communities CRC,
Australian Cotton Research Institute, Locked Bag 1000, Narrabri, NSW 2390,
Australia.
Tel: 0267991533; Fax: 0267991503; Email: nilantha.hulugalle@dpi.nsw.gov.au

Dr Daniel Tan
Lecturer in Agronomy, Faculty of Agriculture Food and Natural Resources, The University of Sydney, Sydney NSW 2006 Australia
Tel: +61 2 9036 9014 Fax: +61 2 9351 4172, Email: d.tan@usyd.edu.au

Dr Damien Joseph Field
Coordinator of Laboratory and Fieldwork Teaching, Faculty of Agriculture Food and Natural Resources, Ross St Bld, A03, The University of Sydney, NSW, 2006
Ph. +61 2 9351 2527, Fax. + 61 2 9351 5108, Email: d.field@usyd.edu.au

Dr Oliver Knox, Research Scientist
CSIRO Entomology, Australian Cotton Research Institute, Locked Bag 59, Narrabri, NSW 2390. Email: oliver.knox@csiro.au

Project Summary

This summer scholarship project was undertaken by James Terry. James is in his fourth and final year of Bachelor of Science in Agriculture at the University of Sydney and is majoring in Agronomy. The scholarship commenced on 28^{th} November, 2006 and was completed on 21^{st} February 2007.

Background

Cotton (*Gossypium hirsutum* L.) production is very important to the Australian economy. Australia is the third largest exporter and the eighth largest cotton producer in the world. Australia has a reputation for producing some of the world's best quality cotton. Cotton production has become increasingly common due to the higher gross margin when compared to other crops. Crop rotations have become increasingly important in the industry due to declining soil organic carbon. Maintaining or increasing soil carbon levels has become a priority due to soil organic carbon being a good indicator of soil health. Carbon fractions are also becoming increasingly important for monitoring how rotations affect short and long term carbon cycling (Hulugalle 2000).

Carbon can be divided into two main fractions, labile carbon and stable carbon. Labile carbon is readily oxidised and more beneficial to short term soil health. Techniques for measuring soil carbon fractions have changed due to advances in technology (Blair *et al.* 1995). Older methods were based on density separation and filters, but were often inaccurate and did not express accurate changes in fractions. Modern methods are more accurate and less labour intensive using chemical, physical and biological separation. The main criticism of most methods is the cost and time involved in achieving the results (Conteh *et al.* 1997). Measuring microbial biomass in a soil using Ninhydrin reactive-N gives a good representation of the microbial fraction of soil throughout the season and its link to soil health (Martens 1995).

Soil improvements from rotations often have long term rather than immediate impacts on soil fertility and structure. In the short term (1 or 2 years), the change will be minimal. Soil carbon has temporary carbon pools and the effect of rotational crops on soil organic carbon may not be easily estimated. Rotational crops such as sorghum and wheat often result in a slower release of SOC compared to continuous cotton. Therefore, short term soil analyses measure the more labile SOC in continuous cotton trials. However, longer term studies monitor the SOC fluctuations over time and generally, rotations including faba beans and wheat give higher SOC percentages after 10 years.

Aims and objectives

This study evaluated soil organic carbon changes, carbon fraction changes and cotton yield resulting from the use of four different cropping rotations in a grey vertosol at the Australian Cotton Research Centre for the 2006/07 cotton season.

Hypothesis

1. Incorporation of corn and wheat stubble will increase the soil organic carbon, labile carbon and soil microbial biomass
2. Cotton yield will be increased with rotations including corn, wheat and/or vetch

Methodology

There were two ongoing experiments that were used for analysis at the Australian Cotton Research Centre. Both of the experiments were in field D1.

Experiment 1

Experiment 1 had two rotations:

1. Cotton – Fallow – Corn – Fallow – Cotton (CCo)
2. Cotton – Vetch – Corn – Vetch - Cotton (CVCo)

Each rotation had two phases occurring each season, one with corn over the summer and the other with cotton over the summer. This experiment started in September 2005 and has now been going for over one year. Soil samples were taken four times throughout the season (November, December 06, January and February 07). These soil samples were compared with the soil samples from the start of the experiment to look for improvements in soil organic carbon. This experiment was a randomised complete block design with four replicates.

Experiment 2

The experiment had four rotations, but only two were sampled from. These were:

3. Cotton – Fallow –Cotton – Fallow – Cotton (CC)
4. Cotton – Wheat – Fallow – Fallow - Cotton (CW)

This experiment started in September 2002 and has now been going for over 4 years. Soil samples were taken four times throughout the season (November, December 06, January and February 07). These soil samples were compared with the soil samples from the start of the experiment in 2002 to look for improvements in soil organic carbon. The results from this experiment are expected to be more conclusive due to the experiment running for longer with longer term changes in soil organic carbon occurring. This experiment was a randomised complete block design with three replicates.

Data Collection

Each experiment had soil samples taken four times throughout the season at two depths; 0 – 10cm and 10 – 30cm. These depths are located where most of the soil organic carbon changes occur in a soil profile. Throughout the season, plant mapping occurred at fortnightly intervals. Plant mapping included plant height, number of nodes, internode length, square and boll numbers, number of first position bolls and retained bolls. Core break testing for live root numbers occurred three times throughout the season.

The laboratory work undertaken for the experiment has involved pH and EC testing, microbial biomass using the Ninhydrin reactive N procedure, root washing, Walkley-Black soil organic carbon measurements and sodium iodide extraction of the carbon fractions.

Soil samples were also taken from a family farm called 'Belah' which is located 5 km south west of Wee Waa. Rotations including wheat and corn are used on the farm and this data was used to provide independent data from a commercial enterprise.

Results and Discussion

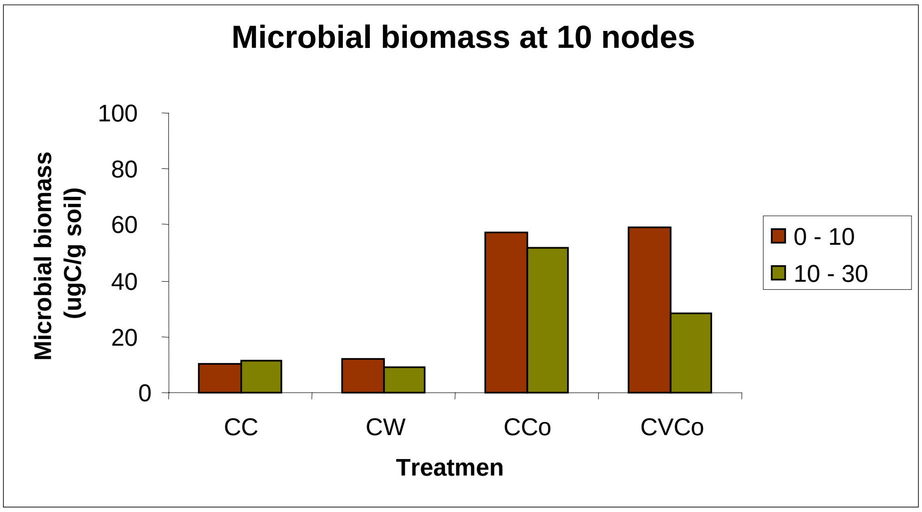

Figure 1. Microbial biomass for the four rotations [Continuous cotton (CC), Cotton-Wheat-Cotton (CW), Cotton-Corn (CCo), Cotton-Vetch-Co (CVCo)] at approximately 10 nodes.

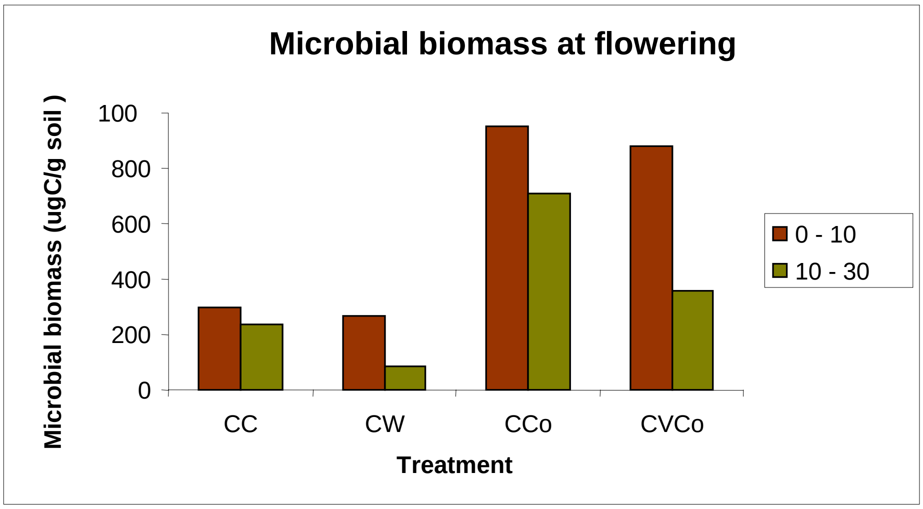

Figure 2. Microbial biomass for the four rotations [Continuous cotton (CC), Cotton-Wheat-Cotton (CW), Cotton-Corn (CCo), Cotton-Vetch-Corn (CVCo)] at peak flowering

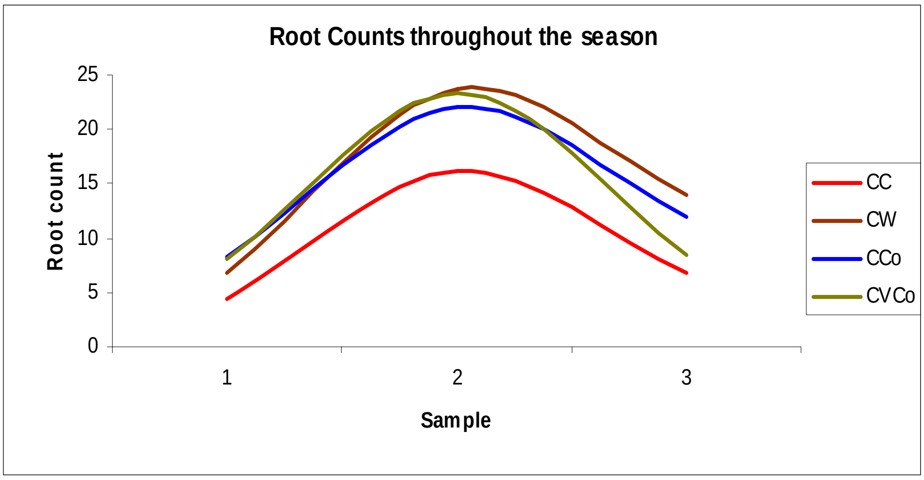

Figure 3. Root counts from core break method throughout the season

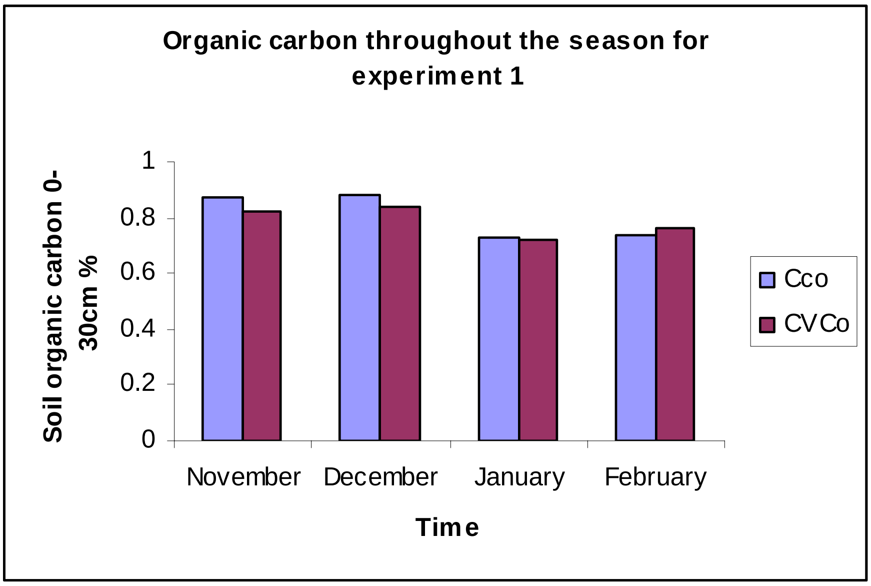

Figure 4. Organic carbon % in 0 – 30cm layer for experiment 1

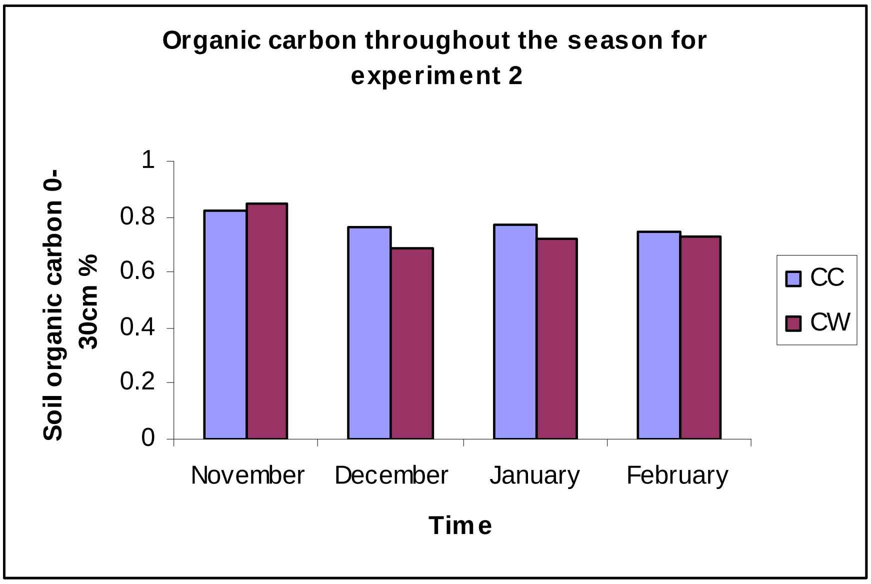

Figure 5. Organic carbon % in 0 – 30cm layer for experiment 2

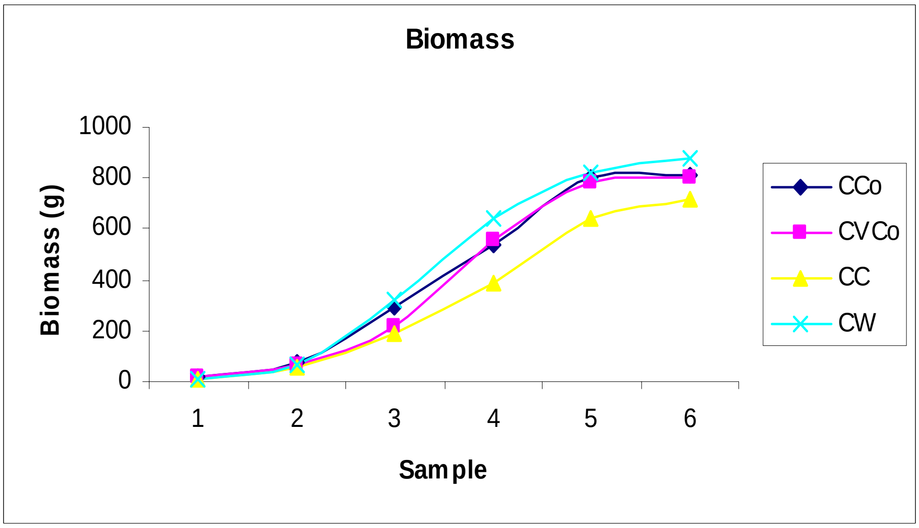

Figure 6. Above ground biomass accumulation throughout the season for the cotton plants of all four rotations [Continuous cotton (CC), Cotton-Wheat-Cotton (CW), Cotton-Corn (CCo), Cotton-Vetch-Corn (CVCo)]

Figure 7. Fruiting sites per metre throughout the season for all four rotations [Continuous cotton (CC), Cotton-Wheat-Cotton (CW), Cotton-Corn (CCo), Cotton-Vetch-Corn (CVCo)]

Microbial biomass increased over the season to a maximum in January. Previous studies by Leuff *et al.* (2006) showed that the microbial biomass reached a maximum at peak flowering. The rotations with corn had significantly higher microbial biomass than the continuous cotton rotation. CVCo in experiment one which involved vetch showed very little difference to the CCo with a fallow winter, indicating that corn is the main contributor to microbial biomass in the rotations (see Figures 1 and 2). The total live root counts using the core break method were far higher for the cotton wheat (CW) and the corn rotations (CVCo and CCo) compared to the continuous cotton rotation (CC) (Figure 3).

The organic carbon changes throughout the season were minimal with small declines of 0.1% organic carbon from November to February occurring for all four rotations. This is expected as there is minimal input into the soil throughout the growing season. The biomass inputs occur generally during autumn and spring. The continuous cotton (CC) and the cotton wheat (CW) rotations had approximately 0.15% organic carbon less than the rotations which involved corn (CCo and CVCo) (Figure 4 and 5). This suggests that over the short time that the corn has been included in the crop rotations, the added biomass is increasing soil organic carbon, compared to the more traditional rotations in experiment 2.

The plant mapping throughout the season showed very little variation between the cotton-wheat, cotton-corn and cotton-vetch-corn rotations. However, the continuous cotton rotation yielded lower with fewer fruiting sites and less biomass per m^2 throughout the whole season. The total fruiting sites were the highest in the cotton-wheat rotation, but substantial fruit shedding occurred in late January possibly due to water stress (see Figures 6 and 7).

Conclusion

From the literature, there are some areas of the soil organic carbon cycle that are not fully understood and there is a need to provide a method of carbon fractionation that is relatively cheap and accurate. There is an increasing need for farmers to know more about soil fractions and how they are changing over time and what inputs are required to increase or maintain the current levels in soils. The effect of crop rotations with high biomass crops is important to increase the level of inputs into the soil. Total carbon changes in soil are often minimal over a one year experimental period so longer experimental periods are required for more meaningful trends. Labile carbon is more rapidly changed as a result of management practices and it is therefore important to measure the soil labile carbon to determine short term effects from management practices such as crop rotations.

Cotton farmers alter the soil in many ways to produce cotton more efficiently. Many soil altering processes impact the soil structure and organic carbon. Soil organic carbon is one of the key measures of soil health. Crop rotations have an effect on both the cotton yield and soil organic carbon. However, there is limited information on which crop rotation combination produces a more sustainable environment while still maintaining profitability. Recent research has been conducted on the use of wheat for crop rotations, and introducing corn into a rotation may be potentially effective in increasing soil organic carbon due to the addition of large amounts of carbon back into the soil. Based on these preliminary results, corn could potentially be included in cotton-based rotations in the Australian cotton industry as a method of better managing soils and improving cotton yields.

Presentations and public relations

Report was presented on the 23rd of February 2007 at ACRI and a thesis proposal was presented on the 21st of March to academics of the Faculty of Agriculture Food and Natural Resources at the University of Sydney

References

Blair GJ, Lefroy RDB and Lisle L (1995) Soil carbon fractions based on their degree of oxidation, and the development of a carbon management index. *Australian Journal of Agricultural Research* **46**, 1459-66

Conteh A, Blair GJ, Macleod DA, Lefroy RDB (1997) Soil organic carbon changes in cracking clay soils under cotton production as studied by carbon fractionation. *Australian Journal of Agricultural Research,* **48,** 1049-1058

Hulugalle NR, (2000) Carbon sequestration in irrigated vertisols under cotton-based farming systems. *Communications in Soil Science and Plant Analysis* **31,** 645-654

Luelf N, Tan DKY, Hulugalle N, Knox O, Weaver T, Field D (2006) Root turnover and microbial activity in cotton farming systems. 13th Australian Society for Agronomy Conference (Australian Society for Agronomy: Perth).

Martens R (1995) Current methods for measuring microbial biomass C in soil: potentials and limitations. *Biological Fertility and Soils* **19**, 87-99.