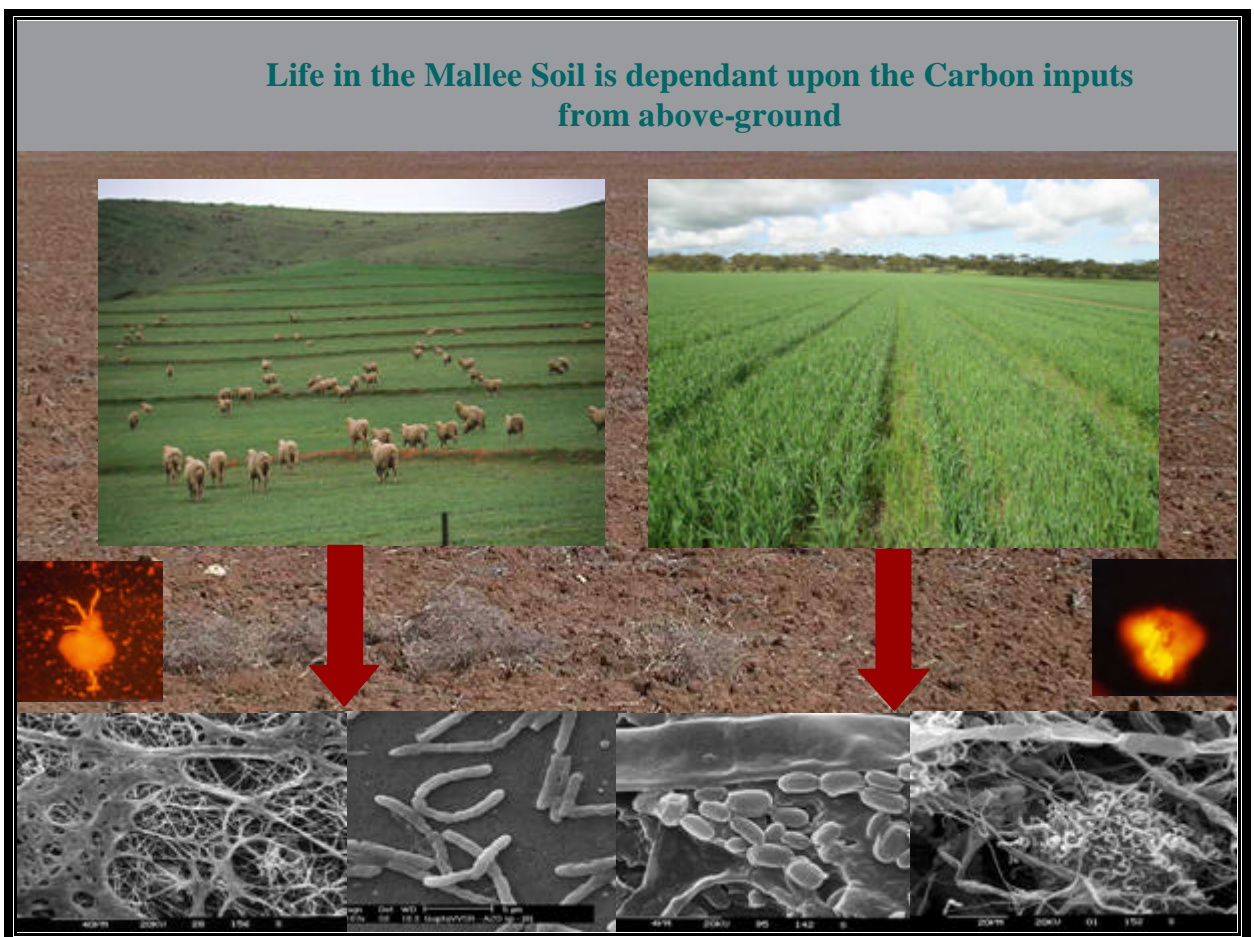


# GRAIN AND GRAZE

## MALLEE

### Soil Biodiversity Monitoring Results 05

Life in the Mallee Soil is dependant upon the Carbon inputs from above-ground



G&G Soil Biodiversity Monitoring Sites

# Soil Biodiversity

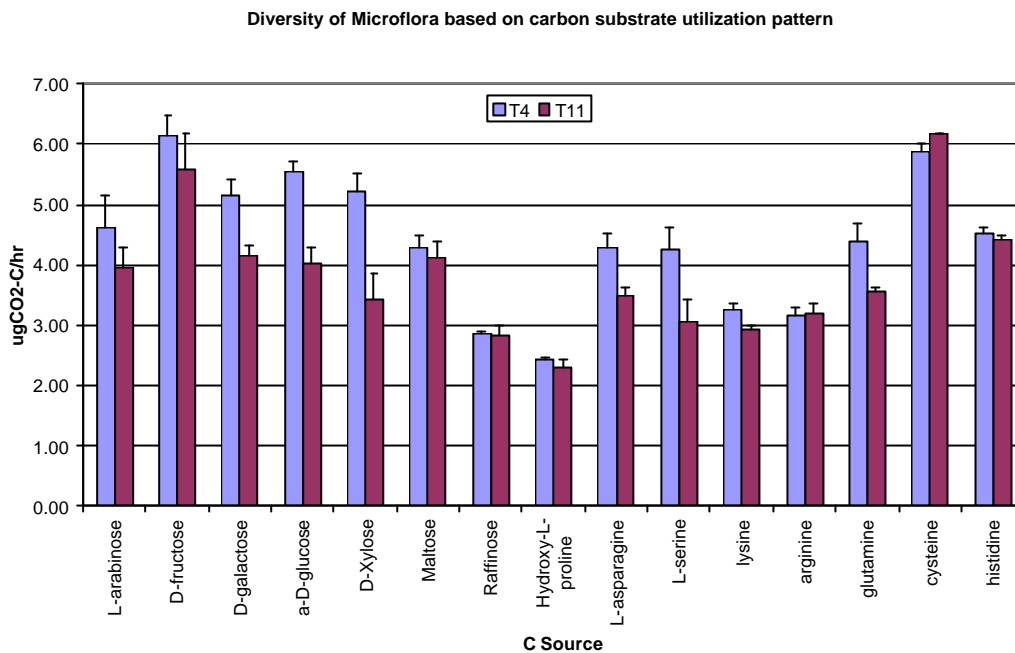
**Biodiversity below ground – Impact of grazing on biodiversity and function of soil microbiota in Grain & Graze systems in Mallee soils.**

## Summary of results

### **Evaluation of methods to measure the functional diversity of soil micro-organisms involved in carbon cycling**

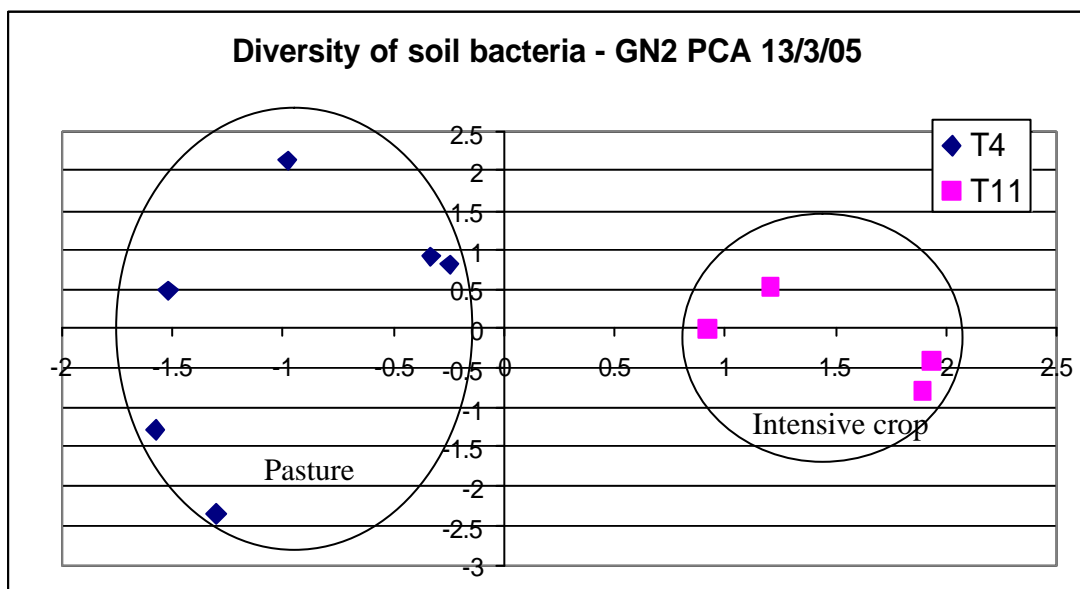
For this we collected surface (0-10cm) soil samples from two treatments, i.e. 'pasture-wheat (T4)' and 'continuous crop (T11)' treatments in the Waikerie core experiment were collected during the summer of 2005. Soil samples collected from 8 different locations in each plot were bulked to obtain a composite sample. All the samples were prepared by gentle sieving through a 2mm sieve to remove large pieces of stubble and stones followed by moistened to field capacity and incubated at 25 °C for 7 days prior to using various analyses. The three types of laboratory methods tested to measure the diversity of soil microbial communities involved in C turnover include: (1) BIOLOG-GN plate methods, substrate induced respiration method using (2) Microresp-soil method or (3) McCartney bottle SIR method. In order to determine the resilience of microbial communities, sub-samples of soils from both treatments were incubated in 1L jars for 21 d followed by the diversity measurements. Resilience of the communities was estimated based on the loss of community ability to respond to added C substrates.

Results shown in Figure 1 indicate that the soil microbial community in both the treatments has the capacity to utilize a diverse array of carbon substrates and the rate of use differs for different C-substrates. The different types of substrates tested in this assay represent substrate types that are commonly known to occur in root exudates and fresh crop residues. The average level of C-substrate usage was higher for microbial community in the pasture-wheat rotation compared to the continuous crop rotation; however this trend was only seen with some C-substrates. Data in Figure 2 shows that principle component analysis can clearly distinguish the two microbial communities suggesting the suitability of this technique to differentiate microbial communities in these soils.

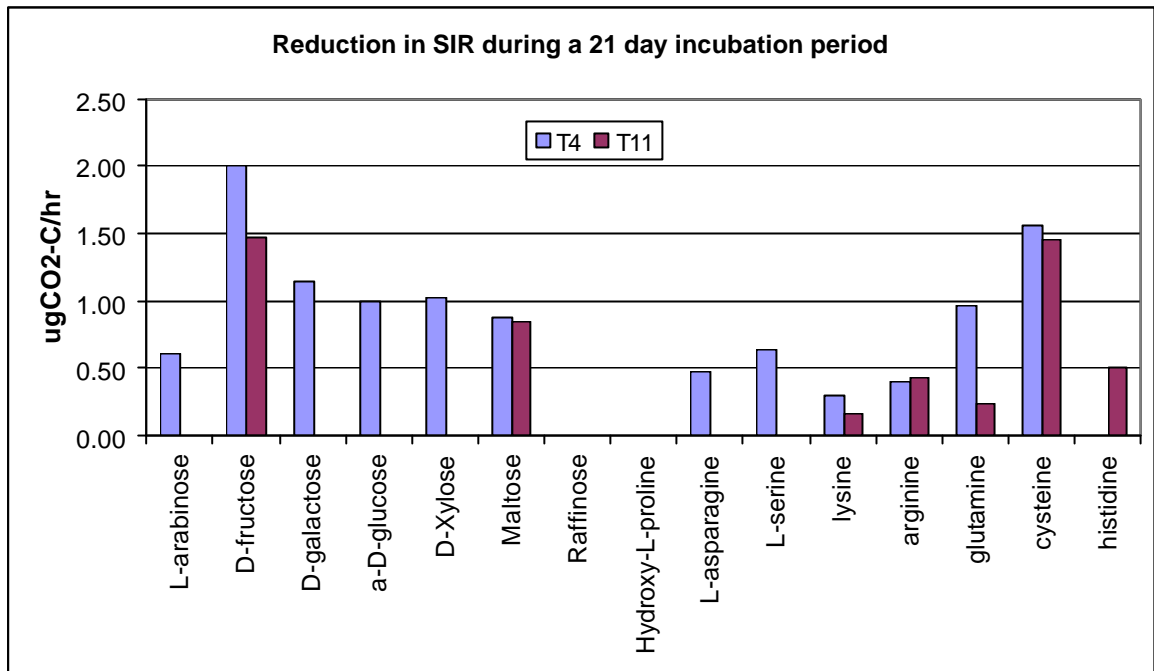


**Figure 1.** Diversity of soil microflora in pasture-wheat and continuous crop rotation systems at Waikerie core site as measured using C-substrate utilization profiles

Note: surface soil samples collected from ‘pasture-crop’ (T4) and ‘Intensive crop’ (T11) treatments in the Waikerie core trial (MSFP) during summer 2005 were used to determine microbial diversity using the ‘Microresp’ method.



**Figure 2.** PCA chart of Carbon substrate utilization profiles obtained using the BIOLOG-GN2 plate method showing significant differences between the bacterial diversity in soils under ‘pasture-crop’ and ‘intensive cropping system’.



**Figure 3.** Resilience of microbial communities under pasture or crop rotations as determined by the loss of their response through carbon substrate utilization abilities (SIR-substrate induced respiration).

Resilience of a microbial community is defined as the ability of a community to withstand changes due to disturbance events that can affect food resources and/or impact the soil habitat. We measured the C-substrate utilization profiles for soil microbial communities in both treatments after 21 day incubation with optimum moisture conditions and at 25 °C. Results indicated a significant decline in the total microbial community (microbial biomass C) and reduction in the ability of communities to use a number of C-substrates. This decline was greater in soils from pasture-wheat rotation compared to the continuous wheat rotation. These results demonstrate that this method is suitable to determine short-term changes in microbial community structure in these soils.

These results suggest that methods based on c-substrate utilization profiles are suitable to determine the diversity and resilience (short-term) of soil microbial communities. Furthermore, results from the three types of lab methods indicated that although all the three methods are capable of delivering similar results, the ‘microresp-soil’ method was most suitable because it allows (i) the use of soil directly unlike the BIOLOG plate method and (ii) high throughput i.e. large number of samples can be handled in a day compared to the ‘McCartney-bottle’ method.

## **Results of laboratory analysis of soil samples collected from two monitor farms in SA in collaboration with Chris McDonough, PIRSA.**

SA: First (pre-grazing) sampling - from October 2005

Monitor farm 1 – feed gap and phase farming near Karoonda

Monitor farm 2 – Sown pastures with increased production near Karoonda

Objective: To compare differences between pastures under different management and intensive cropping systems in relation to the diversity of functional groups of microbiota involved in C turnover and identify links with nutrient (N) availability.

Surface (0-10cm) soil samples were collected inside or near the cages used for dry matter sampling and transported to Adelaide labs and samples were stored at 4 °C until analysis. In order to remove the variability due to differences in soil moisture in samples from different paddocks, all the samples were moistened to field capacity level and pre-incubated at temperatures similar to field conditions for 3 days prior to microbial and biochemical analysis

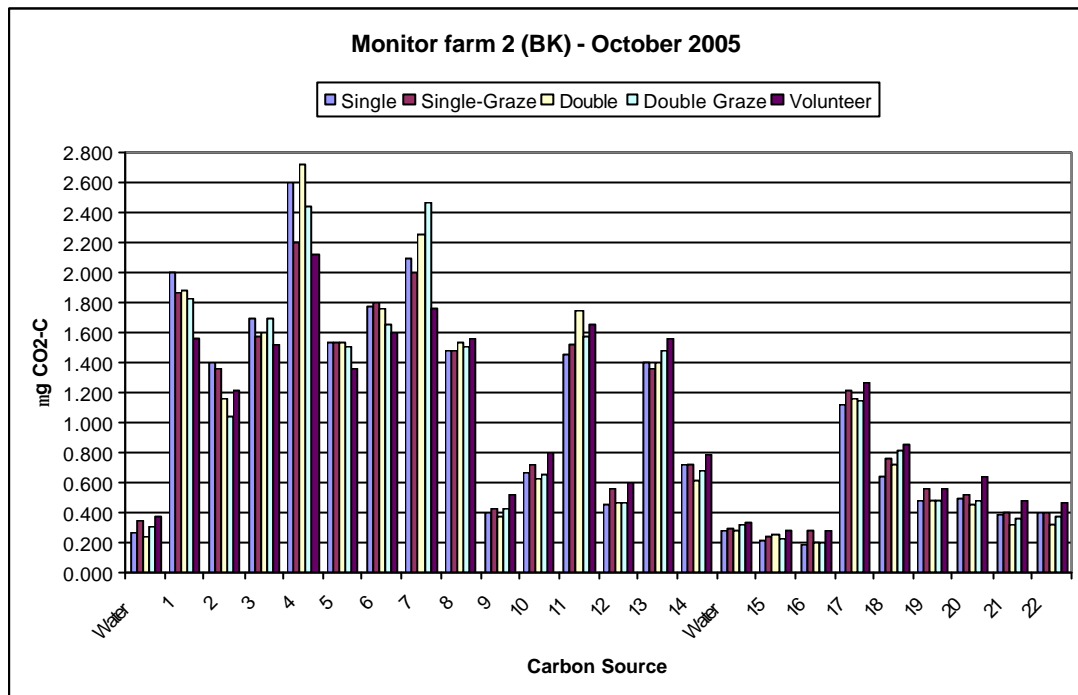
### **October sampling:**

#### ***1. Monitor farm 2 (BK)***

Soil samples collected from the three pastures sown to increased production were analysed for various microbial properties. Samples were collected from within wire cages installed to exclude inputs from sheep and grazing was simulated by removing plant material manually. The three treatments are termed as: Single, Double and Volunteer. Full details of the above ground production are reported by Chris McDonough, PIRSA. Briefly, above ground dry matter production from the October sampling was highest in the 'Double sown' treatment (5,337 kg/ha) compared to the 'Single sown' and 'Volunteer' treatments (3,865 and 2,692 kg / ha, respectively). Microbial biomass nitrogen levels in the surface soils ranged from 28-37 mg N/kg and the soil from Volunteer pasture with lowest MB-N level. Microbial activity levels exhibited similar trend i.e. 4.25 to 5.25  $\mu\text{g CO}_2/\text{g/day}$  in the Single and Double sown treatments and 3.6  $\mu\text{g CO}_2/\text{g/day}$  in the Volunteer treatment. Above ground plant biomass data indicated lowest DM in the Volunteer pasture treatment suggesting that microbial biomass and activity in the pastures reflect the C inputs from above ground. Mineralization of N in soils depends up on the quality and quantity of substrate and the level of microbial activity. Results from potential N mineralization assays indicate lower net N mineralization in the Volunteer pasture soils (9 mg / kg N in a 21 day assay) compared to 12-13.5 mg N / kg soil for Single and Double sown pasture soils.

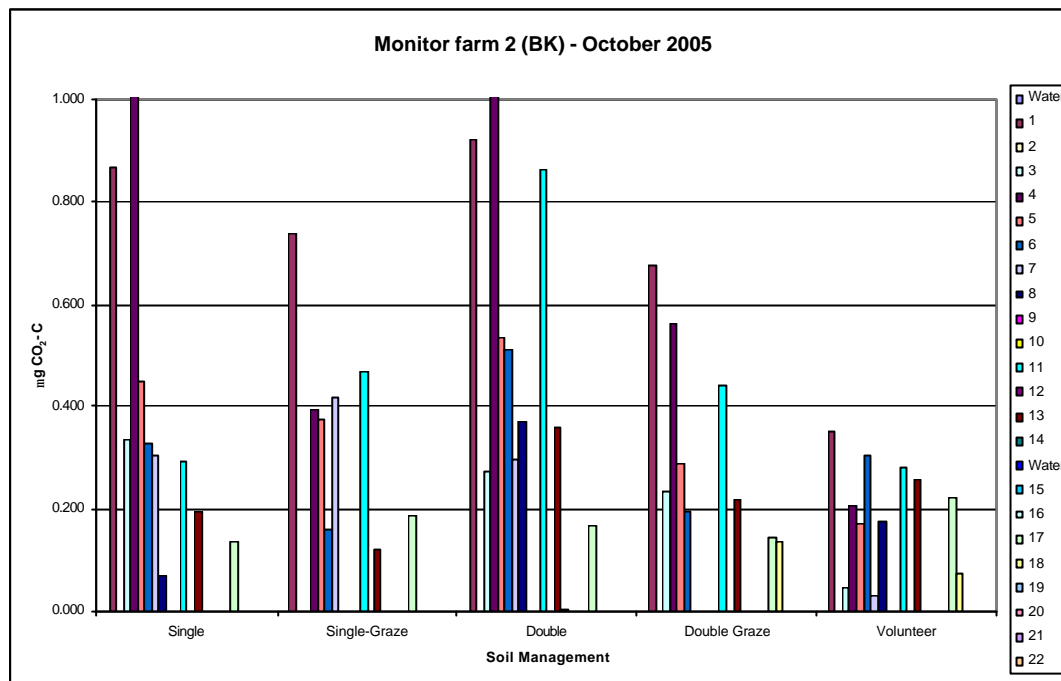
Results in Figure 4 show that 16 out of 22 carbon compounds were utilized by microbial communities in all soil samples where as the use of other C-compounds was very low or negligible. Although some differences can be seen between soils from different treatments further analyses is required (statistical) to determine any significance in particular relationship with C-inputs and microbial functions such as N mineralization. In addition to the three field treatments we also collected soils from Single and Double sown crop at sites that were previously grazed. Results indicated small differences in MB-N where as a significant drop in MB-N values in soils from grazed sites under 'Single

sown' treatments suggesting the differential influence of plant removal under the two systems.



**Figure 4.** Carbon substrate utilization profiles for surface soils from Monitor farm 2 (October 2005)

Results from similar analysis for these soils following 3 or 6 weeks of laboratory incubation indicated a decline in the microbial community's ability to utilize C-substrates in all soil samples. However the level of reduction was different for different substrates and different treatments (Figure 5). These results clearly indicate that not only the functional diversity of microbial communities involved in carbon turnover is influenced by the different pasture systems but also the resilience of these communities is affected by the various treatments. It is interesting to note the level of reduction is different for different C substrates within a treatment and the type of substrates that are affected also differed between different pasture systems. We have completed the laboratory analysis for soil samples collected in December 2005 from these sites and the data analysis is currently in progress.



**Figure 5.** The level of reduction in C-substrate utilization by microbial communities following 6-week incubation. Note the differences in substrates with a loss for different treatments.

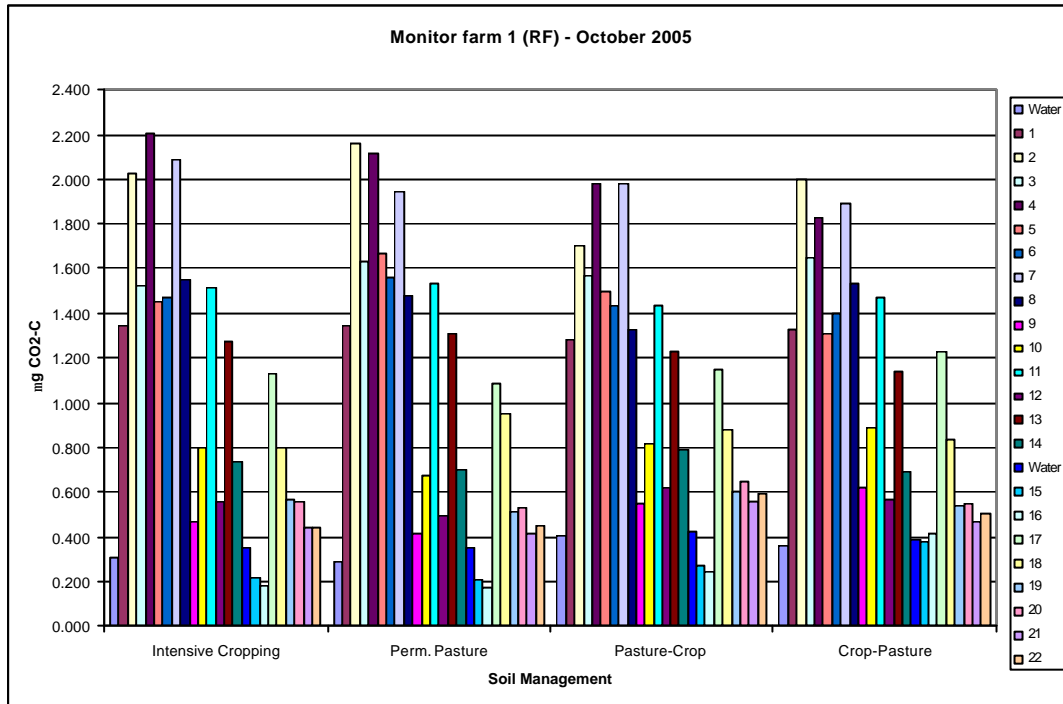
## 2. Monitor farm 1 (RF):

Soil samples collected from the 4 farming systems were analysed for various microbial properties. They include: Intensive cropping (IC), Permanent pasture (PP), Pasture-Crop (PC) and Crop-Pasture (CP) systems. Samples were collected from close to wire cages installed to exclude inputs from sheep. Full details of the above ground production are reported by Chris McDonough, PIRSA.

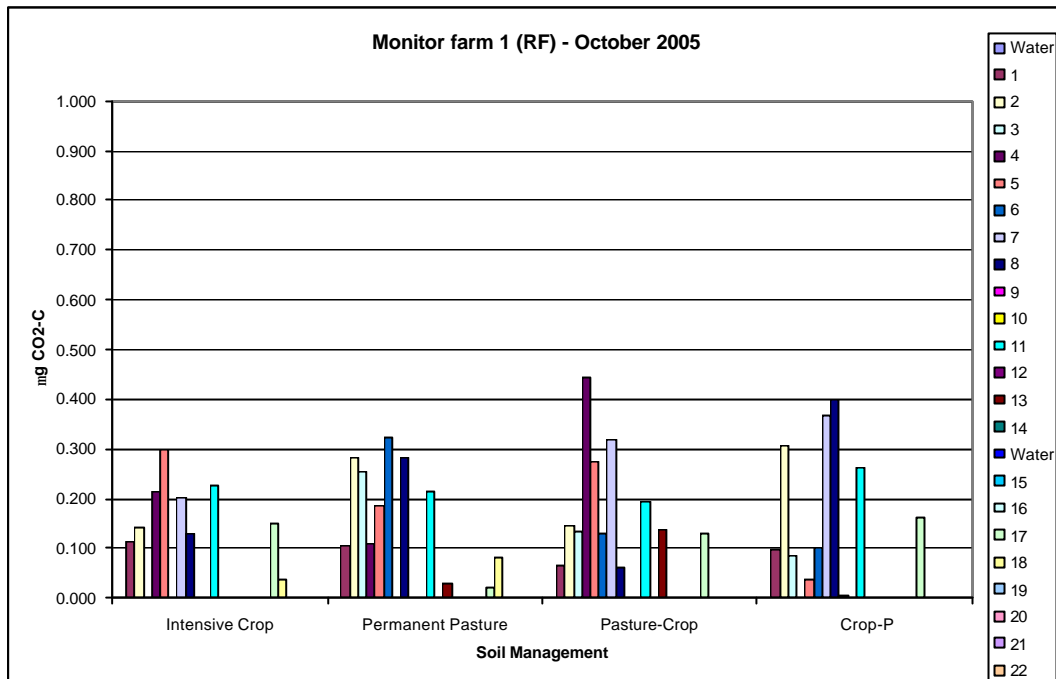
Briefly, above ground dry matter production from the October sampling was highest in the 'Intensive crop' treatment (2,865 kg/ha) compared to the 'Permanent pasture (1,653 kg / ha), Pasture-Crop (2,107 kg / ha) and Crop-Pasture (2,163 kg/ha) systems.

In general the MB-N and net N mineralization levels were higher for the IC and PP treatment soils compared to the PC and CP soils. For example, MB-N levels were 32-39 mg N / kg soils in the IC and PP soils compared to 19-21 mg N / kg in the CP and PC soils. Microbial activity (amount of C mineralized during a 21 day incubation period) levels showed a similar trend. One interesting observation is that even though the above ground dry matter data for the PP treatment was lower than the PC and CP treatments the MB-N and mineralization values were higher for soils from PP treatment. Populations of micro-organisms and levels of microbial functions such as N mineralization are not only influenced by the quantity of C inputs from above ground plant material but also by its quality. These results suggest that we need to obtain more information about the quality of C inputs in different treatments.

Results presented in Figure 6 show that 20 out of 22 C-substrates were utilized by the microbial communities in all samples indicating its diversity. The level of use of various substrates differed for different soils suggesting differences in the overall diversity. The level of use of substrates 9, 10 and 12 was very low in soils from the Monitor farm 2 compared to the soils from Monitor farm 1.



**Figure 6.** Carbon substrate utilization profiles for surface soils from Monitor farm 1 (October 2005)



**Figure 7.** The level of reduction in C-substrate utilization by microbial communities following 6-week incubation. Note the decline in these soils was smaller than that observed for soils from Monitor farm 2.

Incubation of soils for 6 weeks resulted in a decline in the C-substrate utilization capabilities in all soil samples (Figure 7), similar to that observed for soils from Monitor farm 2. However the level of reduction was smaller in the soils from Monitor farm 1.

We are in the process of data analysis for samples collected during Dec 2005 and January 2006. In addition we are working to relate the differences in microbial community diversity and its resilience to soil physical and chemical properties and more importantly to the above ground plant biomass.

## **Summary**

The availability of carbon in grazed systems is mediated strongly by grazing management through above- and belowground plant growth in response to grazing. Plant is the major source of available carbon for biological activity, especially in low fertility Australian soils, hence soil biodiversity and biological activity is more dependant on the quality and quantity of carbon inputs from plants (through root exudation and above- & below ground plant residues).

We measured the diversity and resilience of the microbial community involved in C turnover in soils under different grazed pasture/cropping systems at two monitor farms in SA. A summary of results from our first year work include:

- Microbial diversity measurements based on C-substrate utilization profiles provide a good and useful indication of the status of microbial community. We standardized these methods for use in southern Australian soils.
- Pasture systems with increased above ground dry matter, i.e. ‘double sown’, seem to support higher levels of microbial functions and the loss in microbial functional diversity following grazing is small.
- Initial results suggest that below ground microbial diversity is strongly influenced by the above ground grazing system e.g. C-substrate utilization profiles for permanent pasture different to that in pasture-crop rotations.

We plan to relate these changes in microbial diversity and function to above- ground plant dry matter production and soil properties in order to evaluate if a healthy soil biota would not just decompose available carbon but grow and provide a variety of long-term biological benefits.