



IRRIGATION RESEARCH & EXTENSION COMMITTEE

2005



FOR IRRIGATION CROPPERS

**Using organic matter to maintain
the productivity of soils under
intensive cropping**

Paper prepared by

DR PETER FISHER

DPI

Tatura

Tel: 03 5833 5341

Email: Peter.Fisher@dpi.vic.gov.au

IREC

C/- CSIRO Land and Water, Griffith
Private mail bag 3 Griffith NSW 2680

Tel: 02 69601550 **Fax:** 02 69601562 **Email:** irec@irec.org.au

In a nutshell

- Despite the knowledge that adequate soil organic matter is important for maintaining productive soils, there is very little evidence to inform growers about the relative impact of rotation options.
- Through the largest national, and possibly international, comparison of rotations, this Project has shown that a wide range of rotation options are available to increase soil organic carbon levels.
- The data collected so far provides evidence for the message that growers can improve soil structure by adopting intensive cropping rotations that increase soil organic matter throughput.

Background

Despite the considerable amount of research on the role of organic matter, there is still very little clear advice for growers about how specific changes in rotation are likely to change the soil organic carbon content. There is even less information on whether any changes in rotation are going to significantly affect the soil properties that ensure efficient crop production.

It is generally accepted that long periods of pasture will improve the soil organic carbon levels and soil structure. However, few farmers can afford this option, and improvements are not expected to last long on the return to intensive cropping. Retaining stubble is also considered a good option, although its adoption by growers is patchy at best. It is not currently possible to provide growers with a quantifiable benefit they can expect, under their circumstances, from changing to a higher organic matter retention system. This lack of clear understanding of the processes of organic matter management to optimise soil health benefits, while minimising detrimental crop effects, has led to some regions of Australia having high rates of withdrawal from conservation farming. Additionally, there is increasing interest among growers to more proactively and strategically manage their organic matter input by the use of occasional operations such as burning, tillage or green manuring. However, there is limited knowledge on the most appropriate frequency and consequences of these operations.

Finding the answers

The research project, *Maintaining the productivity of soils under continuous intensive cropping*, was established in 2003 to provide robust guidelines on organic matter management for growers. Using a comparison of many different rotation options that growers have available, and by laboratory incubation studies, the relationships between changes in soil properties and organic matter management systems are being developed. The inherent difficulty in measuring soil organic carbon responses to rotational variations is being overcome by identifying paired sites where all conditions can be expected to be similar except for the grower's choice of rotation.

Real situations studied

The project has initially focused on investigating organic matter management systems currently being practised on irrigated crops. Sixteen paired sites were selected, encompassing a total of 32 different rotations, across southern New South Wales and northern Victoria. A range of organic matter management systems are practised at these sites, from no above ground organic matter input, through to full stubble retention and/or the addition of animal manures. At each paired site one management system was designated as 'high organic matter input' with the other as 'low organic matter input'. This designation was not based on any soil information, but only on the estimated relative organic matter inputs for each of the management systems at each paired site, taking account of the rotation history. Soil samples were collected from each site to analyse a range of biological, chemical and physical characteristics at 0–10, 10–20 and 20–30 cm depth intervals.

Rotations do have an effect

Laboratory and modelling studies suggest there should be a cause and effect relationship between the quantity of organic matter throughput and measures of soil biological activity. Although it would be hoped that these relationships exist, field measurements can be extremely variable. This is because the breakdown of organic matter is a complex process, dependent on soil variables such as temperature, water content, and available nutrients, as well as the dynamics of the microbial populations.

More organic matter, higher organic carbon and microbial biomass

Significantly higher levels of total organic carbon (Figure 1), particulate organic carbon, microbial biomass (Figure 2), carbon mineralisation and soil nitrogen were found in the 0–10 cm depth range in those rotations that were designated to have a higher organic matter throughput. The differences between high and low organic matter input systems were greatest in the surface layer (0–10 cm), but were observable to a lesser extent at increasing depths. It is worth noting that total organic carbon, particulate organic carbon, microbial biomass and carbon mineralisation levels at the 10–20 cm depth were approximately half those at the 0–10 cm depth.

This data shows that increased organic matter throughput can lead to “biologically healthier” soils, as measured by microbial biomass. The conclusions are also robust as the data comes from a large variety of different soil types and management systems and the results are consistent across sites.

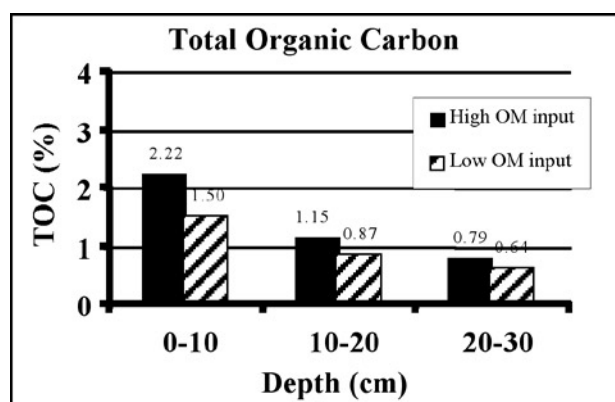


Figure 1: Mean total organic carbon across high and low organic matter input sites, for 3 soil depth intervals. *l*sd = 0.19, *p* = 0.05).

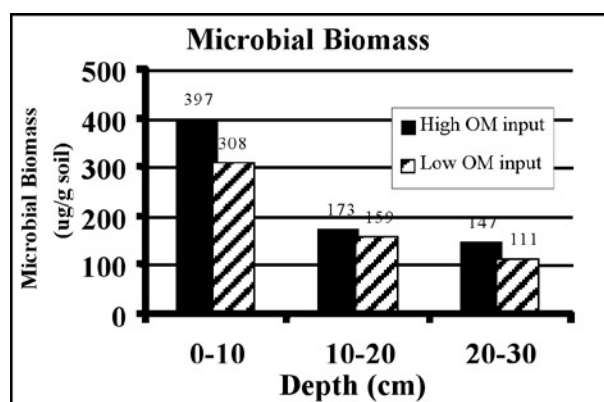


Figure 2: Mean microbial biomass across high and low organic matter input sites, for 3 soil depth intervals. *l*sd = 59, *p* = 0.05).

More organic matter, better soil structure

Increases in soil organic carbon levels or biological health are only important if they translate into an increase in sustainability, the soil's productivity, ease of management; or a reduction in off-site impacts. Improvements in soil organic carbon should improve the physical properties of the soil, such as aggregation and the resistance of those aggregates to be easily broken down. However, it is often difficult to demonstrate a consistent relationship between changes in rotation and soil physical properties, except in laboratory trials or extreme treatments such as pasture phases. This is because soil organic carbon levels can take many years to change and soil structure can also be influenced by many other factors such as texture, soil chemistry, wetting and drying cycles, and traffic.

Analysis of soil physical properties from the paired sites, shows that the rotations designated as greater OM input did result in improved structure. The soil physical test that was most sensitive to the different OM input systems was the measure of percentage water stable aggregates greater than 2 mm (%WSA >2mm). This test showed significantly less breakdown in aggregates in the high organic matter input systems for the 0–10 and 10–20 cm depth ranges, and almost a statistically significant difference at the 20–30 cm

depth range (Figure 3). Plant material is thought to be particularly important for the stability of aggregates greater than 2 mm in size, which is reflected in the improved water stability found for this aggregate size range.

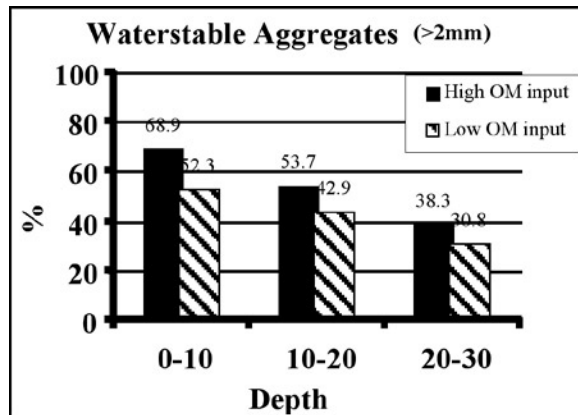


Figure 3: Mean Waterstable Aggregates >2mm. (Isd = 8.6, $p = 0.05$)

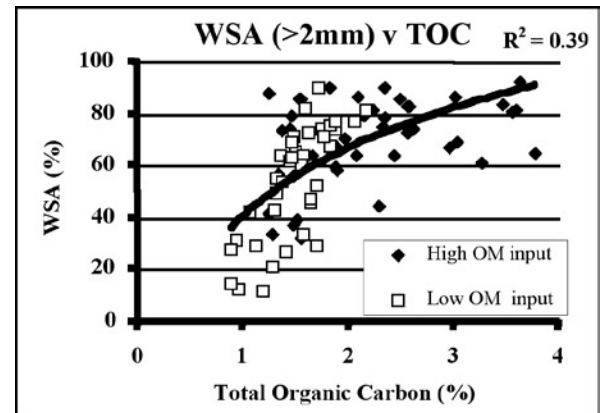


Figure 4: Percentage Waterstable Aggregates and Total Organic Carbon (0–10cm) $R^2 = 0.39$

How much organic matter is required?

Improvement in soil structure is not only dependent on the presence of organic carbon, but also importantly on the activity of the microorganisms that decompose, and thus reduce, the soil organic carbon. It was therefore anticipated that a measure of microbial biomass or microbial activity might provide a more accurate predictor of soil structural improvement than the usual measure of soil organic carbon level. Initial analysis shows that there is in fact a clearer relationship between water stable aggregates and total organic carbon (Figure 4), than there is between water stable aggregates and microbial biomass. However, this relationship requires further investigation because numerous other properties also influence the microbial biomass measurement. The relationship between organic carbon level and water stable aggregates (Figure 4) supports other studies that suggest there is a threshold in soil structure benefit when the organic carbon level reaches approximately 2%.

Local information, global significance

This is the largest national, and possibly international, study to compare the impact of growers' rotations on soil organic carbon and soil structure. The results presented thus far provide powerful evidence, hitherto not available, that subtle changes in rotation can lead to improvements in soil organic carbon levels. More importantly, it has shown that the management practices that have increased the soil organic carbon in each paired site, on average resulted in a measurable improvement in soil structure.

The data provides positive support for the message that rotations with greater organic matter conservation can be used to improve the soil's structural stability. The project methodology of using a large number of paired sites has provided unique quantification on the role of organic matter management. Establishment of the link between improved soil structure and any economic, management, or environmental benefits, is even harder to quantify. However, growers know well the importance of good soil structure, and through a review of the literature and continued discussion with growers, the project will illustrate potential financial and management benefits.

GRDC Project No: DAV 00022

Project Team: Peter Fisher, Clive Kirkby, Jan Skjemstad, Colin Aumann, Alison Fattore, Rob Fisher, John Lacy, Janine McGowan, Annabelle Simson, Abdur Rab, John Thompson, Ann Murray, May Fleming, Matt McRae, Lindsay Evans and Jarrod Brown.