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Managing Soil Biology – Benefits from Nutrient Efficiencies and Disease Suppression

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The issue

Soil biological function in southern Australian dryland cropping soils is regulated by the amount of available carbon, which is required by soil microbes for a source of energy. Australian soils are inherently low in biologically available carbon, in particular in the light textured Mallee soils. Therefore, carbon inputs have a major influence on soil biological activity. Carbon inputs may come from above and below ground crop residues and root exudates from growing plants.

What we know

Key Soil Biological Functions

- Stubble decomposition/soil organic matter turnover
- Nutrient turnover
- Disease control (suppression)
- Plant growth promotion
- Soil aggregate stability
- Pesticide and herbicide degradation

Management of the soil biota can impact on the profitability of the farming system in a number of ways:

- Increased yield
- Increased management flexibility (rotation selection)
- Reduction in input costs (nutrient efficiencies)
- Improved product quality (protein, oil content)

In addition, management of the soil biota helps maintain and improve the quality of the soil resource.

Nutrient Efficiency

In farming systems where the key production constraints (biological or non biological) have been addressed, there is potential to obtain further economic benefit through higher microbial activities resulting from the increased carbon flow in more intensive, higher producing systems. An evaluation of three long-term intensive cropping trials in SA has shown a consistent trend for increased efficiency of production (better water use efficiency) over 10-20 years. This has occurred in the absence of significant disease.

Some of this increase is most likely due to improvements in nutrient efficiencies as demonstrated by:

1. A comparison of a low input pasture-wheat rotation (district practice) with a high input intensive cropping rotation at Waikerie, SA, demonstrated the ability to change soil microbial activity to increase nutrient efficiencies (Table 1). The higher microbial biomass after 4 years of the high input intensive cropping system has resulted in 2 specific benefits:

- A 64% increase in the amount of nitrogen (N) held against leaching. Losses of up to 50kg N/ha have been measured at this site under district practice.
- A 50% increase in N liberation from 20 to 30 kg/ha/yr.

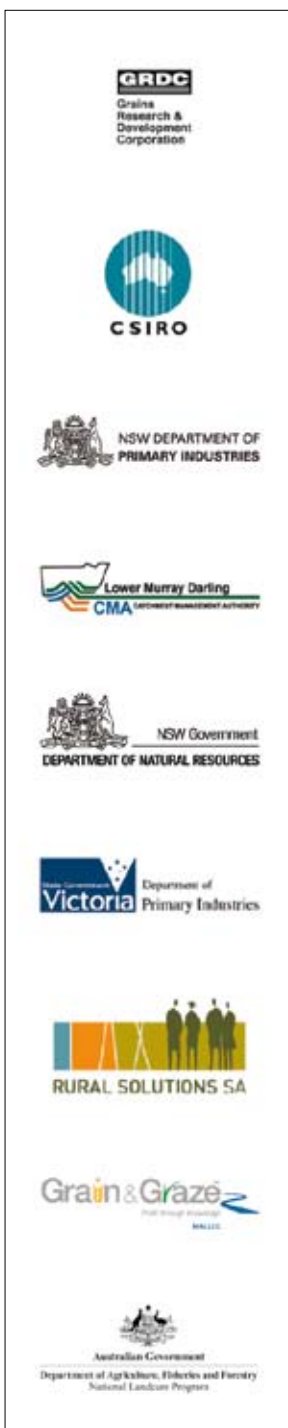
2. Nutrient budgets at Avon, SA, following 17 years of intensive cropping with stubble retention have indicated up to an extra 20kg/ha/yr of 'unexplained' N. This extra N is most likely from non-symbiotic N fixation as a result of high carbon input. This extra N is equivalent to 40% of the total N exported from the paddock.

Treatment	Microbial biomass (mg C/kg soil)	Microbial biomass (mg N/kg soil)	Microbial activity (g CO ₂ /m ² /hr)
Low input Pasture-Wheat	205	21.0	0.075
High input Canola-Wheat	275	34.4	0.250

Table 1: Microbial biomass and activity levels in the surface soils (0-10 cm) of selected treatments at Waikerie core site during July 2002.

Improved nutrient efficiencies impact on the farming system in two ways:

1. Reduce input costs and hence reduce financial risk; and
2. Increase the opportunity for crops to take advantage of exceptional or above average seasons through an increase in the capacity of soil to supply nutrients.



Disease Suppression

All soils have the ability to suppress soil-borne root diseases to some extent through the activity of soil microbes. Studies of changes in severity of rhizoctonia root rot at Avon, SA showed that the levels of disease suppression can be modified over time to the point where complete control of the disease can be achieved (Fig. 1).

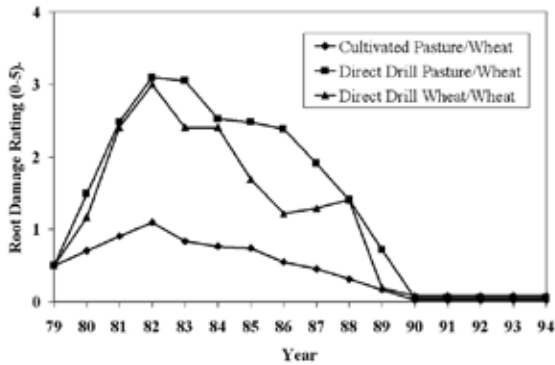


Figure 1. Decline in rhizoctonia root rot of wheat at Avon, SA, 1979-1994.

Increases in suppression were related to increased carbon inputs (stubble, roots) to the soil from higher yielding crops, stubble retention and greater cropping frequency.

Increased carbon inputs result in changes to the composition and activity of the soil microbial community over time. These changes result in greater competition for soil resources that, along with predation and inhibition of pathogens, lead to increased suppression of many soil borne fungal diseases. The development of disease suppression occurred at a faster rate under no-till. However, tillage practice does not appear to change the final level of suppression. Effective soil suppression to disease has now been identified across a range of soils and environments. However, the opportunity to improve suppressive activity may be limited in soils where there are inherent limitations to production (non-wetting sands, highly calcareous soils) due to limited carbon inputs and therefore limited biological activity.

Soil aggregate stability

Soil microbes significantly impact on the aggregation of soil particles and the stability of those aggregates through the production of organic 'glues' and fungal hyphal networks (Figs. 2a and 2b). No-till systems can enhance these microbial effects through less mechanical disruption of the aggregates. In productive intensive cropping systems with stubble retention, the disruptive effect of tillage could be significantly reduced by the associated increase in microbial activity.

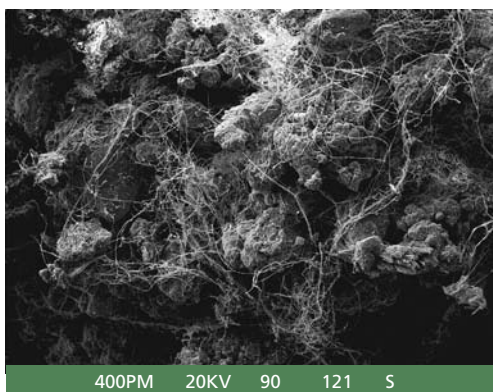


Figure 2a. Fungal hyphae in wheat stubble binding soil particles

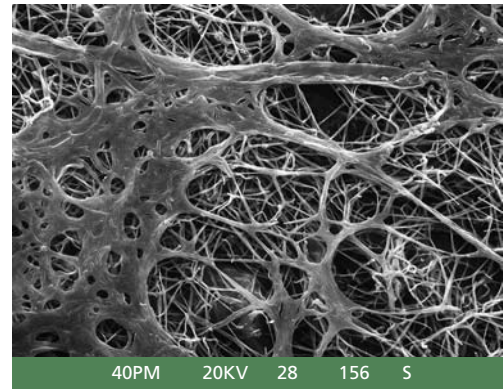


Figure 2b. Production of microbial glues by soil fungi

What this means

The management and utilisation of soil microbial functions is a key factor in both the maintenance of intensive cropping systems in the Mallee and optimisation of their profitability. We now know that well managed intensive cropping systems can actually improve the soil's capacity to deliver the key microbial functions eg. nutrient supply. Microbial activity and function is dependent on the level of carbon inputs, and therefore, as crop water use efficiency improves, the opportunity for greater benefits from soil microbial functions also improves. In contrast, if productivity is low, then the opportunity for soil microbial changes and any potential benefits is limited.

Where to next

An improved understanding of the ability of soil microbial processes to supply nutrients for crop growth allows for a more accurate assessment of the fertiliser inputs required to optimise crop performance. At present our ability to assess optimum fertiliser requirements is limited by soil variability both within and between paddocks. A better understanding of the influence of soil type on soil microbial processes in combination with the new EM38 mapping technologies and variable rate fertiliser application are likely to provide the next opportunities to improved efficiencies of production.

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