Effect of conservation cropping on the diversity and activity of soil biota

Gupta V.V.S.R, CSIRO Entomology and Margaret Roper, CSIRO Plant Industry
Email: Gupta.Vadakattu@csiro.au

Key messages

- Conservation cropping increased the number and diversity of microflora, especially decomposers, and enhanced nutrient cycling. Direct drilling promoted fungi and associated fauna through improved soil structure and increased availability of carbon and moisture.
- Soil carbon decreased over the life of the experiment irrespective of cultivation and stubble management, but the decrease in soil organic matter was least and microbial turnover greatest with stubble retention.

Background

Benefits in soil biological, physical and chemical properties follow the adoption of conservation cropping practices in soils around the world. These practices are associated with increased number, diversity and activity of soil biota. Since the field trial at Harden started in 1989, researchers have followed these changes and the dynamics of soil organic carbon in the surface soil as a result of stubble retention (SR) and direct drilling (DD).

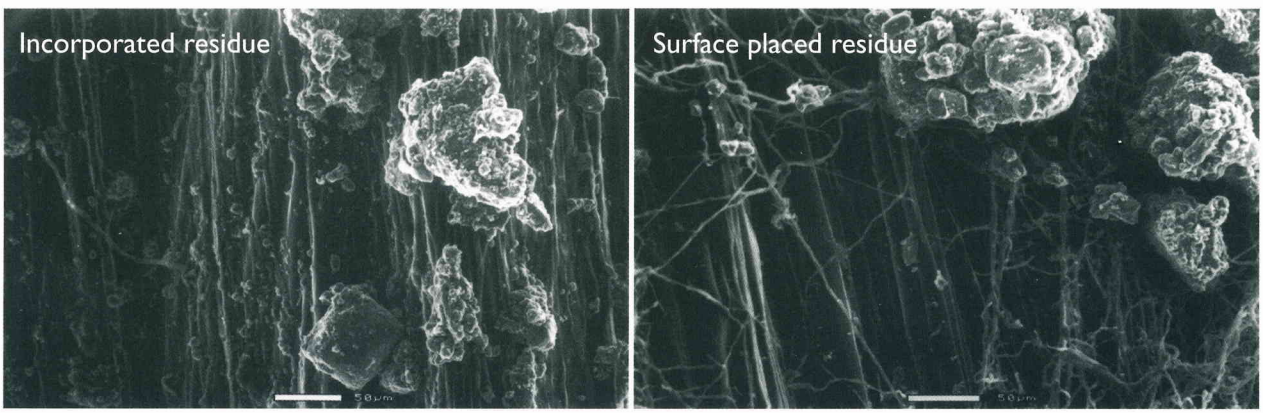
Dynamics of microbial biomass and activity

Microbial biomass (MB), the living part of soil organic matter, constituted 25 to 55 g/m^2 of C in the top 5 cm of soil and the level dropped by 50% with each 5cm depth. Both SR and DD significantly increased MB early in the experiment and the effects strengthened with time. MB accounted for 3% of soil C and 3.75% of total N in the top 15 cm. Stubble incorporation led to a more uniform distribution of MB in the surface 15cm layer than DD. Microbial activity is primarily dependant on temperature, the availability of C and moisture. Field measurements indicated that during May, when soil moisture was adequate, up to 60-70 kg CO_2/ha was released per day. Turnover rates for MB (0.6 to 1.5y) are more rapid than those reported for high organic matter soils in Europe and North America suggesting that MB in this soil and environment acts as a biocatalyst for organic matter cycling and a short-term reservoir of nutrients. SR and cultivation increased N mineralization. Changes in MB early in the experiment were indicators of long-term dynamics of soil organic matter.

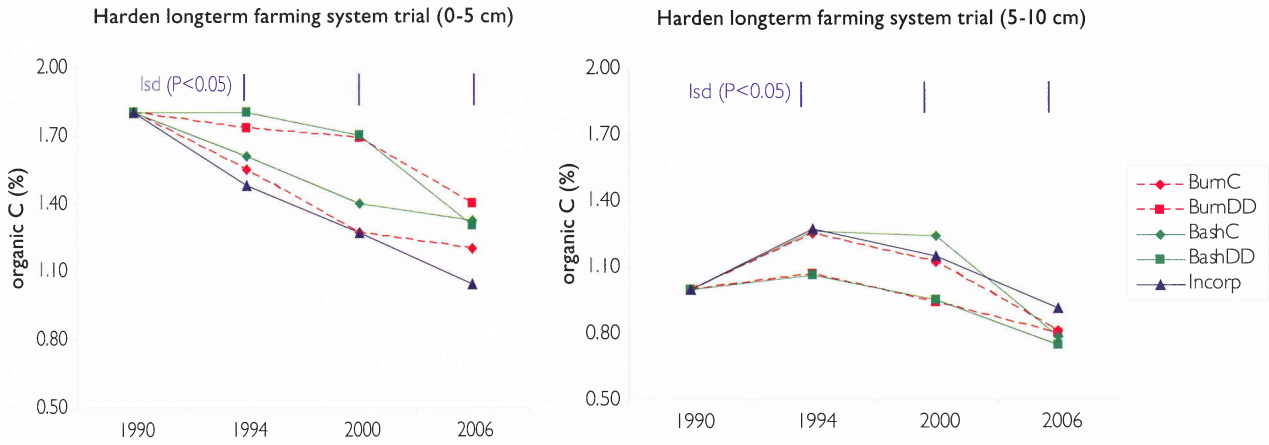
Diversity of Microflora

SR increased populations of microflora, especially cellulolytic bacteria and fungi, within two years of the start of the experiment. DD generally resulted in a fungal-dominated microflora, whereas cultivation promoted bacteria. Six years after the start of the experiment, populations of cellulolytic bacteria, actinomycetes and *Pseudomonas* spp. were higher in the CC soils.

Soil DNA analysis indicated that after 16 years, different stubble managements altered the composition of bacterial and fungal populations. Canola in the rotation altered, transiently, the composition of microflora and accelerated C



> Scanning electron micrographs of soil microorganisms, showing changes due to conservation farming practices. Reduced tillage promoted fungal hyphae (thread like structures) bridging the surface stubble to the soil below. Stubble incorporation supported faster decomposition and bacterial-dominated soil biota.



> Figure 1. Carbon changes in the surface soil, as influenced by stubble retention and tillage at the Harden long-term experiment.

and nutrient cycling. Overall, changes in the populations of microbial communities varied between seasons. Rhizoctonia bare patch was present in cereals but the incidence varied between seasons. It was generally worse with DD and absent where soil was cultivated. Laboratory tests showed evidence of Take-all suppression with DD. This result is consistent with South Australian research indicating that supplying biologically-available C for more than 7 years enhances disease-suppressive microbial communities. Further research is planned on disease suppression in the Harden soil.

Diversity of soil fauna

The surface 10cm of soil contained higher populations and more diverse groups of protozoa and nematodes than the soil below. Mesofauna (springtails and mites) were concentrated below 10 cm during dry periods but more were in the surface during humid conditions. Populations of protozoa and mesofauna were generally higher with DD than cultivation whereas nematodes were not affected. Larger protozoan numbers were associated with greater turnover of MB and higher N availability. Nematode populations were highest in the spring and lowest in autumn whereas mesofauna numbers were uniform throughout the year. DD promoted fungal-feeding species of protozoa and springtails. The diversity of nematodes and mesofauna found was comparable to those in other highly productive agricultural systems elsewhere in the world. Burning stubble resulted in smaller size earthworms due to the reduced amount of food present.

Changes in carbon in surface soil

Microbial activities mediate most of the processes involved with C and nutrient cycling and overall SOM dynamics. Soil C reduced under all the treatments since crops replaced the perennial pasture in 1989. The reduction was greater with stubble incorporation, especially in the surface 5 cm. Late burning of stubble, as applied in this experiment, had limited effect on the decline in soil organic C, mainly due to the availability of C from stubble for microbial use for >3 months after harvest. Some reasons for the loss of soil C are: (i) insufficient C inputs from crop residues to meet the demand by microorganisms, (ii) reduced growth of crops that are the key source of C, due to low rainfall since 2001, (iii) higher rates of decomposition and lower microbial assimilation due to the generally warm environment and (iv) inadequate protection of SOM from microbial breakdown following cultivation.

Practical implications

Results over 20 years show that conservation cropping leads to better overall soil biological health. However, the presence of biological constraints such as deleterious rhizosphere bacteria can prevent these benefits translating into increased grain yield.

Conservation cropping practices improve the soil's potential to supply nutrients (N and P). The change in timing of N release due to SR and DD provides an opportunity to better synchronize N release with plant demand. Reduced tillage is critical to arrest C loss and maintain soil C in annual cropping systems.

This research is being undertaken by Gupta VVSR, Margaret Roper, John Kirkegaard, John Angus, Peter Grace, Mike Hodda, Barry Longstaff et al., Clive Pankhurst, Clive Kirkby, John Buckerfield, Terry Bolger, Andrew Bissett and Bernard Doube.

Further reading

Gupta, V.V.S.R. et al. (1994) Changes in microbial biomass and organic matter levels during the first year of modified tillage and stubble management practices on a red earth. *Australian Journal of Soil Research*. 32: 1339-1354.