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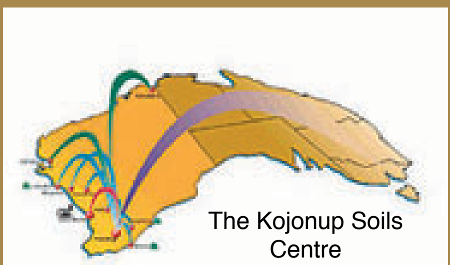
Australian Soil club

Welcome

Welcome to the fifth issue of the Australian Soil Club Newsletter. The ASC is now affiliated with the new Kojonup Soils Centre for administrative purposes. The Kojonup Soils Centre (KSC) is based in Kojonup, Western Australia, for the purpose of disseminating information about all aspects of soil, especially in the farming community, so it will be a valuable association for the Australian Soil Club.



The first KSC seminar was recently held in Kojonup and details of this will be published in the next ASC newsletter.

In this issue:

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Annual membership of the Australian Soil Club is $33 ($40 for overseas subscribers). If you would like to receive further information about the Club, please email Jen Slater: organic@agric.uwa.edu.au

Effect of stubble burning and seasonality on microbial processes and nutrient cycling

by **Frances Hoyle**

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Background

Management practices involving plant residues, such as reduced cultivation and stubble burning, can have a major impact on biological soil N release to subsequent crops by changing the activity of microorganisms in soil (as this is their food source). The amount, type and management of the plant residues can affect both the timing and the amount of nutrients supplied (N, S, P) to the crop.

The effect of long term stubble management is currently under investigation to identify factors influencing microbial activity, soil organic matter-C turnover and related nutrient cycling.

The experimental site (established 1987, G. Reithmuller, W.A. Department of Agriculture) is located on a red-brown earth (heavy clay loam) at Merredin (eastern wheatbelt of WA) and has been used to determine the effect of stubble management on microbial processes. The site has been continuously cropped, since establishment, in a wheat:legume rotation and stubble has been either retained or burnt.

In our investigation, the main aims of the trial were to assess the effect of long term stubble management and temperature (to reflect seasonal differences) on the activity and associated amount of N supply from microorganisms.

Trial details

In 2003, wheat (*Triticum aestivum* L.) cultivar 'Wyalkatchem' was sown at 110 kg/ha after adjustment for seed size and assuming a field emergence of 70%, to achieve a target density of 200 plants per m^2. The trial was sown on 7th June in a randomised block design, with various row spacing treatments and replicated six times.

For the purpose of this investigation, three replicate plots were sampled from both the stubble retained or burnt treatments sown on 180 mm row spacings. All treatments were sown with a basal fertiliser of 150 kg/ha Agras (17.5% N) on narrow points with press wheels.

Initial screening of a range of parameters was conducted prior to sowing to characterise the background soil fertility and biological activity of

Future Directions for Dryland Soil Management Under Direct Seeding Techniques – an Australian Perspective: Part 1

by
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This paper reviews historical and current data on the impact of seeding method on soil quality, confirming that direct seeding techniques create positive benefits to soil quality in an acceptable time frame. From this, critical success factors and key indicators are evaluated, including organic carbon content 0 – 50 mm, soil hydraulic properties, and macropore development and continuity. For landholders and advisors, tactile/visual indicators and field assessments are needed. It is recommended that direct seeding techniques be integrated into the design of farming systems, as part of a 'best practice' approach to soil management and catchment health. Such an approach requires landholders to know the properties of their soils. Landholders should strive to maximise ground cover, minimise soil disturbance, maximise vegetative plant growth, and minimise soil compaction by both machines and livestock. Barriers to adoption of direct seeding techniques need continuing investigation.

Introduction

The relationship between tillage and soil quality has been under investigation for many decades, leading to the development of alternative technologies for crop establishment with an emphasis on reducing soil disturbance. Historically, research efforts have concentrated on reducing erosion - the transport of soil particles together with attached nutrient. Much has been learnt, and methodologies to manage soil erosion are readily available. However, soil quality in general needs further improvement to ensure sustainable crop production in many parts of Australia. Current perspectives of soil quality embrace multiple criteria associated with physical, chemical and biological properties of soil. Management of organic matter remains a critical success factor that relates to these three groups of soil properties.

It is proposed that soil physical quality is central to sustainable crop production. Soil structure determines the partitioning of rainfall at the soil surface between runoff and infiltration, which in turn determines the amount of water available to plants and strongly influences the amount of soil lost to erosion. Soil structure also affects plant root growth and development, the physical habitat for soil biota, and the energy required for ground engaging machine operations. Consequently, management of soil physical quality is selected as the focus of this paper.

Common indicators of soil physical quality include surface infiltration rate, saturated and unsaturated hydraulic conductivity, water holding capacity, aggregate stability, bulk density, pore size distribution, soil strength, penetration resistance, soil carbon content, exchangeable sodium percentage and soil texture. Direct measurement of soil structural form is possible by a number of techniques (Southorn & Cattle 2000). Although these methods generate useful information, they are generally time consuming and difficult to use, and are not commonly reported. As a result, field assessment of soil quality attributes using visual and tactile methods are gaining popularity due to ease of use and reduced monitoring costs, provided some rigour is applied to these observations ; for example, the SOILpak series, including Anderson (et al. 1999), the classification of surface soil types described by Lawrie (et al. 2000), and the establishment of a working group for visual assessment of soil within the International Soil and Tillage Research Organisation. The link with organic matter is important, and soil carbon content is frequently reported. Field and laboratory measurements of these indicators need careful deployment and interpretation; for example, it is still not clear what measurement of soil carbon best reflects its importance to soil physical properties. It is thought that total carbon is an inadequate measure to predict soil physical properties on its own and that some knowledge of the soil carbon fractions is required (Baldock & Skjemstad 1999).

In central west New South Wales (NSW), Australia, the region of interest in this paper, soils are often Red Alfisols characterised by sandy loam to loam surface textures overlying clay loam to clayey subsoils (classified Red Chromosol according to Isbell 1996; surface soils classified as fragile light and medium texture according to Lawrie et al. 2000). Smaller areas of sodic surface soil are also present. Soil quality issues in this region are associated with surface crusting, soil structure decline throughout and below the depth of tillage, compaction associated with wheel and livestock traffic, low organic matter levels, sodicity, acidity, and salinity. These soils typically have a low shrink/swell capacity, and lack the potential for structural self-regeneration. The enterprise mix on most farms includes winter crops (predominantly wheat grown in rotation with other crops and pasture) and livestock (sheep and/or cattle). Sheep are commonly used within a cropping system to assist weed control, reduce crop residue by trampling and fodder consumption, and to add value to the pasture phase of a crop rotation. Although conservation tillage practices have been adopted by many farmers in this region (D'Emden & Llewellyn 2004), this mix of factors has resulted in lower rates of adoption of 'no-till' and 'zero till' than in other areas of Australia. On a more positive note, adoption rates of reduced and zero tillage are likely to increase rapidly in Australia (D'Emden & Llewellyn 2004) and globally (Benites et al. 2003, Gao & Li 2003).

The climate of the region is characterised by dry warm–hot summers and wet cool-cold winters. Mean annual rainfall ranges from 640 mm at Cowra in the east of the region to 495 mm at Trangie in the west, but is associated with high rainfall variability (Cowra 10 percentile rainfall 390 mm, Trangie 255 mm). Winter cropping programs are highly dependent on autumn rainfall, a factor which encourages many farmers to conserve soil water by a period of fallow. In both marginal and excessive rainfall conditions, choice of crop establishment method has proven to be an important factor in timeliness of machine operations.

Although pastures represent a significant land use in the region, and are often incorporated into a crop rotation to assist with nutrient and soil carbon accumulation, disease management and soil structure restoration, the focus of this paper is on methods and impacts of dryland crop establishment methods. It is important to note that crop establishment method is only part of the soil quality debate. Maximising plant biomass is a parallel strategy that must be pursued, in order to exploit improved soil physical quality and water availability, and generate the additional organic matter that is frequently deficient (Oades 1984, Geeves et al. 1995). Consequently, it is assumed that a cropping system has addressed soil limitations associated with fertility and pH.

In our next issue of *The Australian Soil Club* newsletter, Part 2 of this paper will be presented, addressing the following issues:

⇒ **The impacts of tillage on soil physical quality – an overview**

⇒ **Is 'direct drilling' sufficient to improve soil physical quality?**

⇒ **The importance of other components of the farming system**

Photo caption

Glossary

'***stubble***' - the standing crop residue following harvest; '***stubble incorporation***' - the use of tillage machines to chop and bury crop, pasture or weed residue; '***dryland***' farming - rainfed (non irrigated) production systems; '***traditional***' or '***conventional***' ***tillage*** - the use of multiple passes of tillage machines for weed control, grazing and/or burning of the previous crop stubble, followed by seeding; '***reduced tillage***' - the practice of reducing the number of soil workings prior to seeding, stubble burnt, and weed control by herbicide and/or grazing; '***minimum tillage***' - one tillage pass prior to seeding, often with stubble burning, and herbicide and/or grazing for weed control; '***direct drilling***' - one pass at the time of seeding, usually creating full soil disturbance during this pass, sometimes with stubble burning, and herbicide and/or grazing for weed control; '***no tillage***' - one pass sowing but using ground engaging tools (typically tine mounted sowing points) that disturb soil only in the sowing row, often into stubble, grazing occasionally used but including herbicide application for weed control; '***zero tillage***' - one pass seeding using ground engaging tools that place seed without surface soil disturbance into stubble (typically disc type openers), and herbicide application for weed control.

the site. Physical soil and stubble parameters included bulk density, soil moisture and water holding capacity.

Results

Physical soil fertility - The physical status of the soil (derived from its capacity to store plant available water) can be classed as 'moderate' for the burnt and 'good' for the stubble retained treatments.

Chemical soil fertility - Analyses for chemical status of the soil, indicates there are no measurable constraints to yield at this site. A difference in soil total carbon (%) is observed at this site as anticipated, with increased total carbon levels associated with stubble retention (1.21% total C) compared to burnt treatments (0.97% total C).

Biological soil fertility - Soil N released from crop residues and soil organic matter results primarily from the activity of microorganisms. Therefore any change in their activity (microbial respiration; Fig. 1), or their weight/mass (microbial biomass; Fig. 2) can result in changes to the rate of biological soil N supply.

This has been assessed for the retained versus burnt treatments. Microbial activity (Fig. 1) was found to be greater where stubble was retained, particularly at soil temperatures above 10ºC. Stubble retention also resulted in a higher mass of microorganisms in the surface (0-5 cm) layer of the soil (Fig. 2) and similar amounts at greater depth.

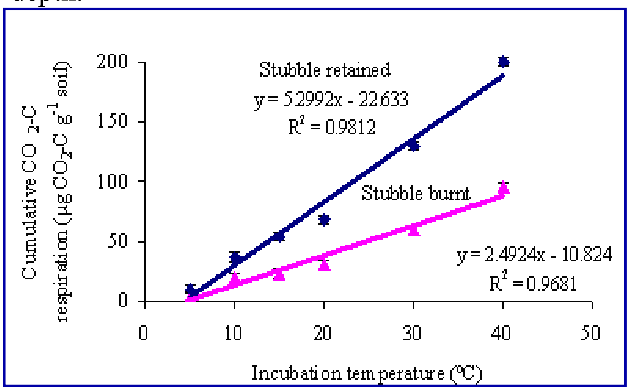

Fig. 1. *The effect of long term stubble management (retained versus burnt) on microbial respiration rates (CO_2-C evolved) at Merredin in 2003.*

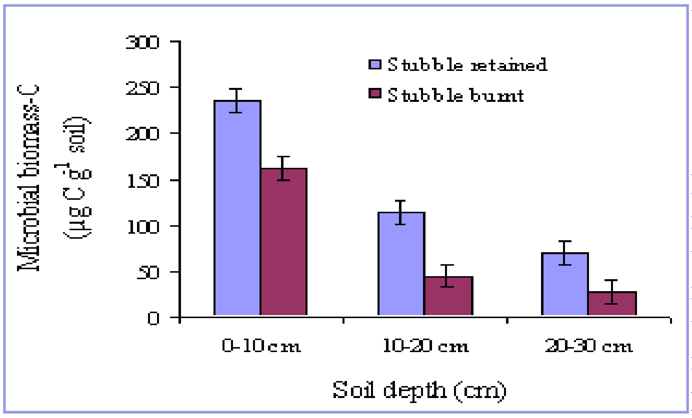

Fig. 2. *The effect of long term stubble management (retained versus burnt) on microbial biomass-C at Merredin in 2003.*

The mass of microorganisms measured to 30 cm depth in this trial was 486 kg per ha C in stubble retained and 348 kg per ha C in burnt treatments. Microbial N was estimated at 89 and 67 kg of N per ha for stubble retained and burnt treatments respectively (data not presented). This means that there is equivalent to 146 kg/ha (stubble burnt) and 192 kg/ha (stubble retained) of Urea contained within the soil microorganisms – a significant source of potentially plant available N.

Changes in the mass of microorganisms and their activity are commonly reflected in changes to the soil supply rate of both C and N. This has been demonstrated in Fig. 3, where it can be seen that at all temperatures tested, the stubble-retained treatments released more soil N than the burnt treatments. Clearly these results illustrate that stubble retention promoted both a larger but also more active microbial community compared to burning.

Grain Yield

Grain yield (estimated by hand harvest) at this site reached 3.07 and 2.28 t/ha for stubble retained and burnt treatments respectively. Grain protein was measured at 9.51% (retained) and 10.96% (burnt). This indicates an N uptake of approximately 292 and 250 kg/ha. The results obtained in this study suggest the relationship between stubble retention and grain yield observed can in part be associated with changes in the amount of N supplied from the microorganisms, particularly at higher temperatures.

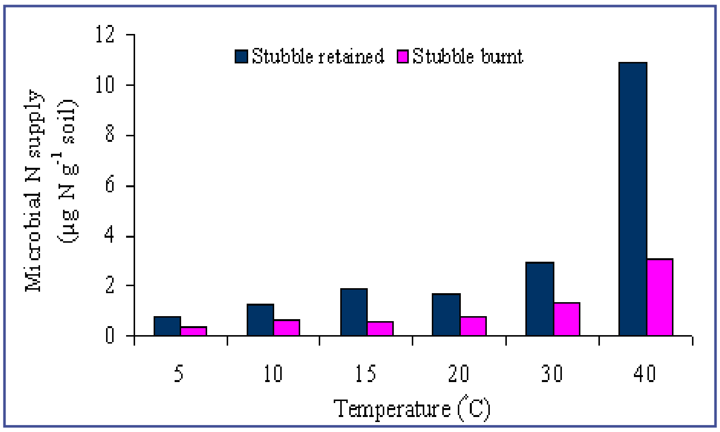

Fig. 3. *The effect of long term stubble management on microbial N supply at Merredin in 2003.approximately 292 and 250 kg/ha.*

Acknowledgements

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