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Australian Soil Club

Welcome

The two articles in this issue are:

- ***Soil organic matter contribution to soil fertility and stability***
- ***Low cost maintenance for water repellency***

There are a number of newsletters on the soilhealth.com website that you may find interesting. They are two page summaries of particular areas and include:

Nitrification
Compost
Mites in soil
Arbuscular mycorrhizal fungi
Rhizobia
Living soil organic matter
Organic agriculture
Viticulture & soil health
Olives and arbuscular mycorrhizas
Fungal/bacterial ratios & soil health
Symbioses

The Australian Soil Club website (www.soil.org.au) has a special section for ASC Members to log into. The past and present newsletters will be placed on the website when they appear from now on but they will not be available to non-members.

We are arranging for ASC Members to get access and we will let you know how to do this when it is set up. The website will also have new information from the Land and Water Australia initiative on soil health which will be relevant to Australian conditions.

The book 'Soils are Alive' has now been prepared for web access and you will be informed when this is accessible to you.

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Soil Organic Matter and its Contribution to Soil Fertility and Stability

Research on this topic was conducted by N. Blair, R.D. Faulkner, A.R. Till and P. Sanchez ('Decomposition of ^{13}C and ^{15}N labelled plant residue materials in two different soil types and its impact on soil carbon, nitrogen, aggregate stability, and aggregate formation.') and was published in the *Australian Journal of Soil Research* on 2005 (Volume 43, pages 873-886)

While conventional farming practices have traditionally involved the removal of crop residues after harvesting, there can be many benefits to retaining these residues, including increased soil fertility, improved nutrient cycling and more stable soil structure. So-called 'no till' farming can also have the added environmental benefit of sequestering carbon within the soil – offsetting greenhouse gases emitted during the decomposition of plant residues.

Although there is growing acceptance that 'no till' farming can improve the structure and fertility of soil, there is still some question as to which plant residues provide the most sustained fertility and stability benefits. A recent study by Blair et al (2005), published in the *Australian Journal of Soil Research* seeks to shed some light on this question.

To investigate the contribution that different plant residues can make to soil fertility and stability, Blair et al took soil samples from a property near Tamworth in New South Wales. The authors investigated the breakdown of residue in two types of soil: a Black Earth comprising 32% sand, 22% silt and 46% clay, and a Red Clay comprising 29% sand, 17% silt and 54% clay. Three different plant residues (medic, rice straw and flemingia leaf) were added to the soil samples to investigate their affect on soil carbon, nitrogen and aggregate formation.

'Carbon Fertility'

While the concentration of carbon decreased from the plant residues in all treatments, the flemingia leaf recorded the lowest decrease over time for both soil types. In just ten days, the medic residues recorded a rapid 55% and 60% decrease in carbon concentration for the Red Clay and Black Earth respectively. By way of contrast, the flemingia leaf recorded only a 15% and 22% drop. After 200 days, only 15% and 22% of carbon was retained in the medic residues for the Red Clay and Black Earth respectively, while 58% and 48% remained in the flemingia leaf. Although the rice straw was found to break down less rapidly than the medic in the first ten days of the study, over the course of the experiment, it recorded a similar breakdown rate.

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Blair et al proposed that plant materials with slow decomposition rates have the greatest capacity to sustain increases in soil carbon over time and reduce mineralisation of carbon to $C0_2$. Accordingly, the most rapid depletion in soil carbon over the course of the study was observed in the quickly decomposing medic treatments, while the slowest depletion of soil carbon was recorded in the flemingia treatments. Indeed, the flemingia leaf treatments were shown to provide the highest total soil carbon after a 200 day period. Blair et al (2005) concluded that, in practice, flemingia residues would provide a high rate of carbon sequestration and slow release of nutrients for cropping activities.

It has been previously theorised (see references in Blair et al) that rapid breakdown of plant residues is predominantly dependent upon the residues having a high percentage of labile carbon in combination with high nitrogen concentrations. Although both medic and flemingia both have high labile carbon percentages and nitrogen concentrations, the Blair et al (2005) study observed very different breakdown rates for these plant residues. The authors therefore propose that other factors contribute to flemingia leaf's slow breakdown rate: for example, its high percentage of polyphenols, tough leaf cuticles, high protein binding capacity and low dry matter digestability percentage. It would appear that the decomposition rate of plant residues is a more complex matter than has been previously proposed.

Nitrogen Fertility

Unlike carbon depletion, nitrogen losses were not significant for the majority of the plant residues. In fact, loss of nitrogen was only observed in the medic samples after ten days (19% was lost from the Red Clay and 20% from the Black Earth samples). After this period, no further loss of nitrogen was observed from any of the plant residues. Blair et al (2005) proposed that the initial loss of nitrogen from the medic residue was due to its rapid rate of initial decomposition, resulting in a high percentage of nitrates for denitrification. Although no significant difference in soil nitrogen was detected from the beginning to the end of the study for any of the treatments, soil nitrogen was increased compared to a control sample for all the treatments. Blair et al's 2005 results supports Aita et al's 1997 theory (*European J Soil Sci* 48, 283) that more carbon is lost from soil than nitrogen because internal nitrogen cycling retains nitrogen, whereas carbon is lost from the soil through mineralisation to carbon dioxide.

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Soil Aggregate Stability

Aggregate stability was measured using the MWD test (Amezkeka 1999 *J Sustainable Agric* 14,83), which measures the size and distribution of soil aggregates. Blair et al (2005) found that soil stability was directly related to the breakdown rate of plant residues and carbon fertility. Indeed, a rapid increase in soil stability was observed for the medic treatments in the first days of the experiment, related to medic's initially rapid rate of breakdown. However, as the study progressed and carbon was lost from the system through mineralisation to $C0_2$, stability declined. The rice straw treatment (Black Earth) also led to an increase in MWD up to 20 days followed by a rapid decrease in stability; however, in the Red Clay, the MWD stabilised after 20 days. The flemingia treatments were the only samples to increase MWD over the entire duration of the experiment, reflecting this plant's slow decomposition rate. By the end of the experiment, the MWD of the flemingia treatments was nearly 80% improved in the Black Earth samples and 37%-33% improved in Red Clay samples. By way of comparison, the medic treatments were only 25%-27% improved in the Red Clay and 44% improved in the Black Earth.

The stability of the Black Earth samples improved significantly more than the Red Clay samples for all treatments in the Blair et al study. In fact, an improvement in stability was even evident in the control sample (without the addition of any plant material), in which MWD was observed to improve by 27%. These results demonstrate the capacity of Black Earth to improve in structure without the addition of organic matter, confirming Oades' 1993 (*Geoderma* 56, 377) proposal that biological factors are less important for improving structure in clay-rich soils.

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ASC Mission Statement
To provide information about soil that is relevant to all land users.

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By way of contrast, the strong correlation between carbon concentration and MWD in the Red Clay samples reveals the importance of organic matter in maintaining stability in this less clay-rich soil type.

Soil Aggregate Formation

Blair et al. (2005) found higher carbon percentages in the outer layers of the soil aggregates from all plant residues treatments in comparison to the control. The authors proposed that newly added soil organic matter accumulates in the outer layers of aggregates, with the greatest accumulation over the 200 days occurring for the residues with a slow breakdown rate. Indeed, the flemingia treatments were found to have particularly elevated levels of carbon in the outer layers of soil aggregates. Blair et al proposed that the breakdown products of plant residues act as a binding agent – allowing macroaggregates to form when smaller aggregates bind to old aggregates, contributing to improved soil stability. In the long-term, the authors suggest that macroaggregates reduce mineralisation of carbon to $C0_2$ by protecting soil organic matter from decomposition in an anaerobic environment and through increased contact with clay surfaces.

In Conclusion

Blair et al. (2005) suggested that 'no till' farming can improve the fertility and stability of soil through enhanced incorporation of organic matter and formation of macroaggregates. This farming practice minimises soil disturbance and maximises the addition of organic matter – allowing for surface organic matter to be incorporated into the soil through microbial activity and for soil aggregates to form through the activity of binding agents. Although tillage has the potential to disturb soil aggregate stability, Blair et al suggested that soil structure can nevertheless be improved using conventional farming practices if disturbance is minimised and plentiful organic matter is added to compensate for mineralisation to carbon dioxide.

Blair et al. concluded that plant residues which provide a sustained supply of soil binding agents and nutrients have the greatest potential to improve soil structure and fertility in the long term. Further research into the decomposition of various plant residues is required to understand which rotations or green manures can provide the most effective nutritional releases and the most sustained contributions to soil aggregate stability.

*Reference:*Blair, N., Faulkner, R.D. Till, A.R. and Sanchez, P. (2005) *Australian Journal of Soil Research 43, 873-886*

Low Cost Management for Water Repellency of Soil

Research on this topic was conducted by M. Roper ('Managing Soils to Enhance the Potential for Bioremediation of Water Repellency') and was published in the *Australian Journal of Soil Research* in 2005 (Volume 43, pages 803-810)

Water repellency occurs in siliceous sands across five million hectares of southern and western Australia. These sands cause many agricultural issues as a result of uneven infiltration and restricted soil wetting. In particular, repellent soils require more rain before seeding than non-repellent soils – potentially reducing yield or resulting in germination difficulty. Wind erosion can also become a problem for these dry soils, exacerbated by reduced crop cover from delays in seeding or patchy germination. Water erosion that would not normally occur with non-repellent soils may occur in repellent soils after heavy rain on slopes.

Significant research has taken place to understand the causes of water repellency and reduce its effect on Australian agriculture. When organic matter decomposes it can produce waxes which form a water repellent layer around sand particles. These waxes are generally composed of long chain hydrocarbons, fatty acids and alkanes. Coarse sands are particularly prone to developing repellency, due to their decreased surface area for wax adhesion. There is also some evidence that sheep pastures and blue lupin crops are associated with water repellent soils. (Agriculture Western Australia, Farm Note: Water Repellent Soils http://agspsrv34.agric.wa.gov.au/agency/pubns/farmnote/1996/F10996.htm)

While there is significant evidence to show that the addition of kaolinite clay to water repellent soil can improve wetting, the amount of clay required is significant. The addition of clay to water repellent soils therefore represents an expensive solution for properties without naturally occurring deposits.

There has been some anecdotal evidence from farmers that the addition of lime to water repellent soils can also improve wetting. A recent publication in the *Australian Journal of Soil Research* (Roper, 2005) tests this theory using both laboratory tests and field studies to compare the repellency of soils after the addition of lime, clay or water.

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Addition of Water

In both field and laboratory studies, Roper investigated the addition of water to repellent soils, using the MED test (King 1981 *Australian Journal of Soil Research* 19, 273) to measure repellency. Laboratory samples, taken from a site near Woogenellup in Western Australia, were initially highly water repellent (MED3.9). After the addition of water and a period of incubation at 30 degrees Celsius, the MED of these samples dropped to 2.5, while samples incubated without the addition of water remained severely repellent.

This finding was consistent throughout field study results. At an irrigated field site in Anketell, south of Perth, soils with varying irrigation histories were tested for repellency. Roper found that repellency decreased as the time soils had remained permanently wet increased. In particular, her results showed severe repellency in non-irrigated soils (MED4.1), but only minor repellency in soils irrigated continuously for seven years (MED2.4).

Addition of Clay

The affect of kaolinite clay on the repellency of soils was investigated in the laboratory and at a dryland field site near Woogenellup. As has been shown in previous studies, the addition of clay to the laboratory samples reduced repellency significantly. After sixteen days of incubation, repellency had dropped from MED4.9 to only MED1.8. Thereafter, only a minor decrease in repellency was observed (the MED dropped to 1.3 after 161 days). At the Woogenellup field site, addition of clay to soil was shown to reduce water repellency after a period of one year; however, a degree of repellency returned during the hot dry summer months.

Addition of Lime

The addition of lime to repellent sands was tested in the laboratory and at both field sites. Confirming anecdotal evidence from farmers, Roper discovered that the addition of lime and water to her laboratory samples reduced repellency after a six month period of incubation. In fact, lime was shown to reduce water repellency from MED4.9 to MED1.8 after a period of 16 days, while repellency dropped to only MED0.7 after 161 days. The affect of lime on water repellency was also evident at the two field sites. In the irrigated site at Anketell, the addition of lime dropped MED from near 1 to 0 after only 35 days; while at Woogenellup, repellency also dropped – although seasonal fluctuation was again evident.

Physical or Biological Response?

Roper proposed that the addition of water, clay or lime to soil can diminish repellency through either a physical or biological interaction. She suggests that the rapid decrease in repellency observed after the addition of clay and lime to laboratory samples indicates a physical interaction - with particles of clay or lime binding to the surface of sand particles and covering their hydrophobic surfaces.

Roper also proposes that lime can reduce soil water repellency by increasing populations of wax degrading bacteria that prefer alkaline soils. The much slower reduction of repellency in the limed samples after a period of sixteen days suggests an additional biological response, caused by the growth in populations of wax destroying bacteria. To validate this theory, Roper tested populations of wax degrading bacteria in a range of samples. As predicted, the addition of lime increased populations of these bacteria tenfold compared with untreated samples.

Roper also proposed that the decline in repellency in the permanently wet samples at the irrigated site at Anketell, as well as in the moist laboratory samples, was due to growth in populations of wax degrading bacteria in the moist conditions. Likewise, the seasonal increase in repellency evident at the dryland site a Woogenellup may have been caused by decreased populations of wax-degrading bacteria in the dry summer conditions. In these months, the addition of lime and clay was shown to have a long-term affect – improving soil wetting in comparison to control samples, despite the dry conditions.

In Conclusion

Roper suggested that the addition of lime to water repellent soils is a viable and cost-effective alternative to the addition of Kaolinite clay. In particular, far less lime than clay is required to improve wetting – resulting in decreased water requirements for improved cropping potential.

Reference: Roper, M. (2005) *Australian Journal of Soil Research* 43, 803-810