Deep incorporation of organic matter- what is actually happening down there?

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Following the success and consistently high yields of deep incorporation of chicken manure demonstrated by Peter Sale of La Trobe University and Renick Peries of Vic DPI, SFS have taken the next step in investigating the factors driving these benefits.

Is it the nutrients in the manure that is boosting yields?
Is it the organic matter and nutrients combination increasing the bucket size?
Or is it the disturbance of soil in the rooting zone through deep ripping that benefits growth?

Key findings in first year:

- In year one of this trial, there was no yield differences observed with the application of chicken manure, artificial nutrients or no nutrients
- Cultivation with the mouldboard plough resulted in better yields compared to no cultivation or deep ripping in the first year regardless of nutrients
- Grain protein was significantly higher in the chicken manure treatments
- Large amounts of dry matter was produced under the manured treatments however it didn't make any difference to yield

The objective of this trial was to determine the effect of subsoil manuring on crop performance, specifically to investigate which component of subsoil manuring gives the crop a boost. It is not clear whether it is the composition of the manure which gives benefits (organic matter, N) or the practice of deep ripping and disturbing the hostile subsoil (regardless of manure), or even just the nutrient value of the amendment.

Background: subsoil limitations in the HRZ and the move to subsoil manuring
Crop performance in the high rainfall zone of southern Australia continues to be limited by the hostile subsoils that are common to this region. These duplex soils have a distinct texture contrast between a light surface soil overlying a dense clay subsoil. The main problem with these heavy clay subsoils is that they lack porosity, restricting the movement of air and water as well as root growth. They are typically sodic, prone to waterlogging and can severely restrict plant access to water and nutrients at depth.

The practise of subsoil manuring evolved because farmers in high-rainfall areas were unable to reach the yield potentials they expected given our long growing season, mild spring temperatures and high rainfall. Although the introduction of raised beds had given some good results in waterlogged soils, many crops were simply running out of moisture, especially during dry springs.

Subsoil manuring involves the incorporation of organic amendments such as chicken manure 30-50cm deep into the soil. Trial results to date have shown that it improves the physical properties of dense clay subsoils, resulting in deeper root penetration, more plant available water and improved nutrient cycling. This translates to yield increases of up to 60% as well as a minimum 10% increase in plant water use efficiency.

Although results have been promising and interest from farmers high, the adoption of this technology is a challenge due to the sheer volumes of manure required and the high cost in terms of time, effort and money. Ongoing research intends to bridge knowledge gaps specifically related to improving cost effectiveness, exploring the nature of the soil amelioration process and crop yield response and the development of suitable machinery for broad acre use.

Figure 1. Distinct soils in the high rainfall zone consist of light surface soil over a dense clay subsoil.

What we did

Treatments:
The treatments include four tillage/cultivation techniques which saw manure/artificial/none placed deep with the SFS prototype machine, surface applied and deep ripped and surface applied and ploughed in. Three amendment treatments including composted chicken manure, artificial nutrients (in the form of common fertilisers - matched to the composition of the manure) and no amendment.

Factor 1. Tillage
- None – surface applied nutrients
- Ripped, deep incorporation (previous technique)
- Ripped, surface incorporation
- Mouldboard plough and bury nutrients/surface applied

Factor 2. Amendment
- None
- Artificial nutrients (fertiliser MOP + TSP + SOA)
- Manure (15 t/ha Chook Manure)

Nutrient Target to match manure kg/ha:
N 20, P 76, K 131, S 18, Ca 90

Nutrients were put out prior to sowing. The deep placed manure and nutrients were placed using the SFS subsoil machine which is a prototype designed to place amendments roughly 50cm apart and 40cm deep. Deep ripping cultivation was done with the subsoil machine with no amendments and the ploughing was done with a mouldboard plough which went to a depth of 20cm. Surface applications were spread and raked by hand.

The trial was designed with buffer rows every second row to mimimise the treatments interfering with each other.

Figure 2. Placing chicken manure to a depth of 40cm using the SFS 2 leg subsoiling machine with hopper

Figure 3. Arrows indicating manure placed at depth by the subsoil machine

Did the extra nutrients have any bearing on results?

There were no standout benefits from any of the nutrient treatments on grain yield, regardless of placement. It didn't seem to matter whether nutrients were received in the form of manure, synthetic fertiliser or if there were no extra nutrients put out at all. Perhaps this is because the manure and artificial nutrients were put on in addition to MAP (100kg/ha) at sowing and top dressed urea (300kg/ha) and therefore nutrients weren't limiting. The untreated control still received ample amounts of nutrients for crop growth. It will be interesting to see if the chicken manure has a residual value compared to the synthetic fertilisers applied.

Dry matter doesn't always transform into yield

Manure stimulated plant growth. When manure was applied on the surface prior to sowing, dry matter at GS31 was significantly higher than any other treatment. This effect was visible in the plots compared to the control, with a taller and thicker canopy, see figure 2, below. Considering the artificial nutrients replicated the nutrient component of the manure suggests that other characteristics of the manure were more beneficial to plant growth. Perhaps the nature of the manure means that it stays around for longer in the soil compared to artificial nutrients, which could have been lost. When the manure was placed in the subsoil, dry matter was significantly lower than the surface applied manure which indicates that the roots hadn't yet reached the nutrients.

Although there were obvious visual differences between treatments through the season, these were not backed up with the yields from the header. Deep incorporation of manure is thought to increase the bucket size, allowing the roots to penetrate further and access more water with the manure acting as a sponge, meaning that more moisture is available post-anthesis. With access to more moisture, the crop will stay greener for longer, increasing the time spent in grain fill before crop maturity resulting in heavier grains and greater yields.

Figure 4. Deep ripping + surface applied manure (middle plot) compared to untreated plots showing large amounts of dry matter production prior to GS31

Greenseeker readings taken on the 22nd November indicate that the manured plots had retained more green leaf than those with no added nutrients. The longer a plant can retain green leaf, the longer they are photosynthesising,

in this case putting energy into grainfill. Mouldboard ploughing also seemed to have an effect on green leaf area compared to the other cultivation treatments. Breaking up of the subsoil (ploughed to approximately 20cm depth) using the mouldboard plough may have led to better root exploration and access to moisture later on in the season, particularly given the hard finish.

Did cultivation have any bearing on results?

Cultivation seemed to help things along, with the mouldboard plough treatments showing a yield increase of at least 0.43t/ha (p=0.1) compared to ripping or no cultivation. With the trial conducted on quite heavy ground, ploughing appears to have been beneficial to soil structure and conducive to plant and root growth through the season. Some waterlogging was observed through winter across the trial, but wasn't recorded as having any detrimental effects on one treatment over another.

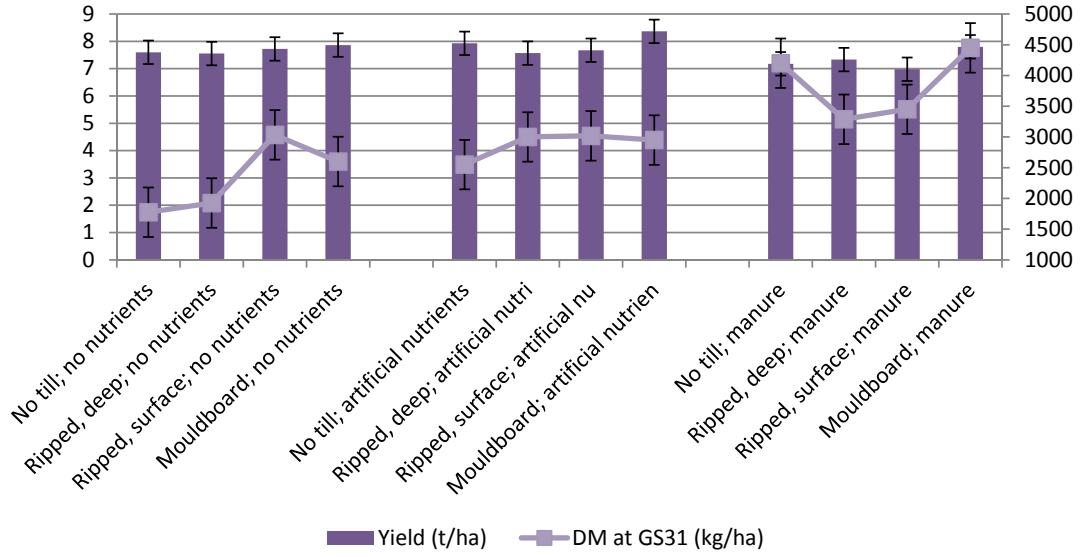

Figure 5. Grain yield and corresponding dry matter at GS 31, confirming that in 2012, early production of dry matter had no correlation on yield

So what about protein?

Given the application of 300kg/ha of urea at stem elongation (GS31) it would make sense that nitrogen was not a limiting factor to crop growth and subsequent protein. It is interesting then, that all of the manure treatments regardless of placement and tillage produced significantly higher proteins than the artificial nutrient treatments or the treatments where no extra nutrients were applied pre sowing. Is there another component of the chicken manure that would contribute to protein? The residual nature of the chicken manure may mean that nutrients were available later in the season to contribute to protein. The manured treatments had an average protein of 12.8% which was significantly higher (p=0.001) than the artificial and no nutrient treatments which averaged 10% protein.

Figure 6 shows that when yields were high, proteins were generally low. Under manure, the proteins were quite high, but yield was lower than the artificial treatments and even the nil treatments. A dilution effect is often observed with higher yields resulting in lower proteins and usually vice versa.

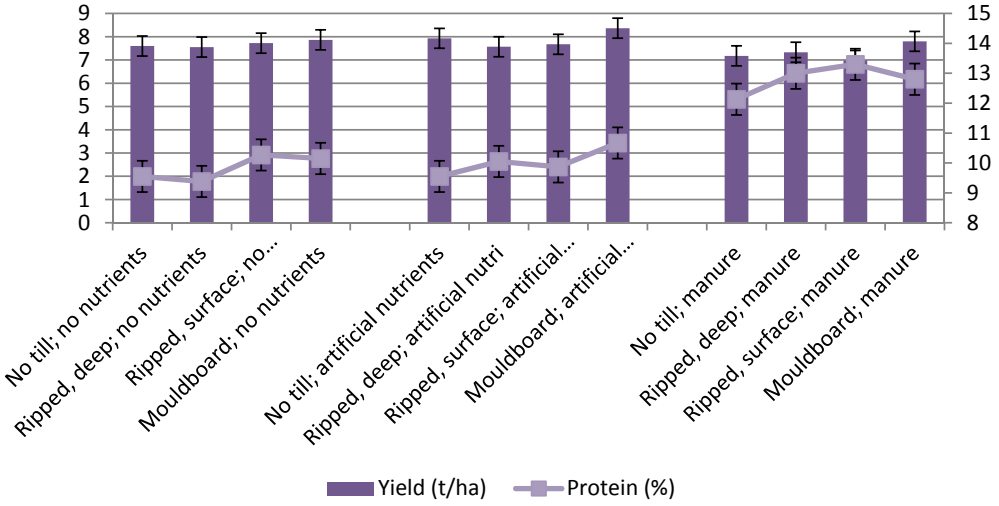

Figure 6. The correlation between grain yield and grain protein under different tillage and amendments. Manure treatments had significantly higher protein (P=.05, lsd 1.05)

What does this mean for my farm?

Incorporation of organic matter into soil will inevitably improve the overall health of the soil over time. Whether or not the initial outlay will be realised in soil conditions and production gain after a few years will depend on the soil type, along with the expectations of the grower. Past trials have shown immediate benefits from application of manure, deep placed and also surface place with obvious residual value being seen years later. With costs nearing $900/ha for deep ripping manure, the grower must seriously consider costs and benefits, which will depend entirely on the starting point of the paddock and the expected response in crop growth.

In this experiment we measured the effect of artificial nutrients versus organic matter (chook manure) and the relationship between placement of these amendments, whether they are deep ripped, ploughed in or applied to the surface. Over the next few years we hope to provide more insight into whether yield increases are due to nutrition, organic matter, deep ripping or a combination of the three when subsoil manuring is utilised. After the first year perhaps we have generated even more questions rather than answers!

Acknowledgements

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References

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