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Research News

September
2005

Ameliorating hostile subsoils in south-west Victoria

Background

In the high rainfall zone of south-west Victoria, waterlogging has been the main limitation to crop production on flat or gently sloping country. Waterlogging occurs as a result of heavy clay subsoils reducing movement of water through the soil profile following heavy rains. Raised beds and controlled traffic (CT) help alleviate waterlogging in broad acre cropping systems, but the full potential of the raised beds is still hampered by a number of recurring problems.

The soils of the volcanic plains generally have dense, rocky and large structural units at depth, that are difficult for crop roots to penetrate. In such cases roots usually follow naturally occurring cracks in the soil but the full exploitation of the profile for water could still be hindered. The efficient use of soil water at depth can also be affected by the chemical nature of the subsoil. Most of the cropping soils are sodic (high in exchangeable sodium) at depth. This sodicity causes dispersion of soil particles, which lead to the collapse of soil structure and loss of pore spaces, affecting the growth and efficient function of plant roots.

The story so far

Studies conducted by Southern Farming Systems (SFS) on Vertosols (cracking clay soils) have shown that following the installation of raised beds the porosity of the soil can improve even below the depth of the initial tillage. As a consequence there appears to be an improvement in hydraulic conductivity (the rate at which water moves through the profile) of the soil at depth, that enhances the movement and storage of plant available water (PAW). However, we are yet to successfully address the issue of low harvest index (the proportion of total dry matter partitioned to grain) in cereal crops, which is most likely a result of the PAW during grain fill being inadequate to meet the higher demand of the bigger crop canopies produced on raised beds.

GRDC
Grains Research & Development Corporation

SOUTHERN FARMING SYSTEMS

State Government Victoria
Department of Primary Industries

Some management options for heavy clay subsoils

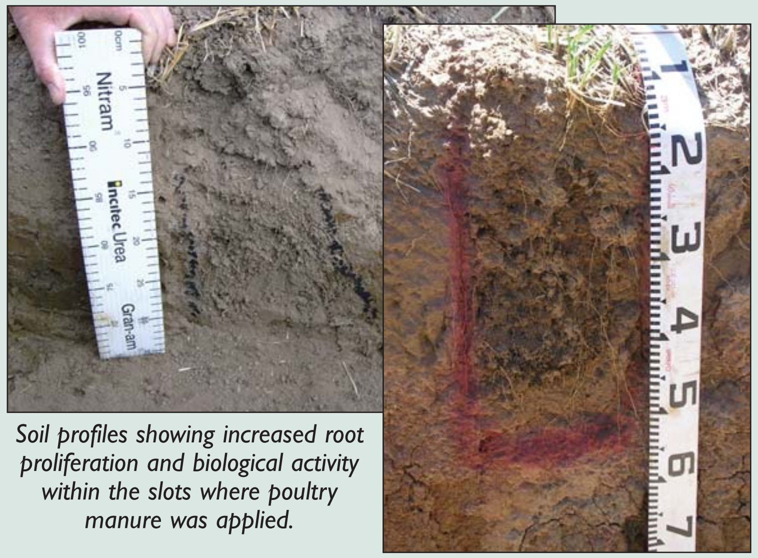
a. If you are mixed farming on dense subsoils, consider a 4 to 5-year lucerne phase in your farming system to help repair your compacted subsoil (Biological ripping). To help reduce soil compaction due to grazing, it is best to remove animals from the paddock when soils are wet.

b. Consider cultivating or ripping the soil to 10-15cm depth immediately after the lucerne is removed. This will break up any compaction that animals may have caused to the surface soil. (Take care not to carry out ripping when the soil is too dry or too wet).

c. When ripping, consider trying the idea of incorporating some porous material such as dry poultry manure, wool scour waste or rice hulls. Some of these materials may even get into deep cracks and may help maintain soil porosity and aeration during the cropping phase. This will also help with the uniform re-wetting of the subsoil. Organic and porous material closer to the surface can provide other soil struture benefits through improved biological activity and increased connectivity between topsoil and subsoil.

d. Rip-lines created by a deep ripper are also a good pathway for addition of gypsum into sodic subsoil. Evidence suggests that in most soils of the region a rate of 5.0 t/ha may be sufficient. Try the gypsum in two split operations; initially to get 4 t/ha of the gypsum down to problem depth and subsequently the balance of 1 t/ha spread on the surface. This is to prevent surface crusting resulting from some sodic subsoil being brought to the surface by the ripper.

e. It could be an advantage if there is some rainfall between deep ripping with gypsum and the re-forming of the beds. This will help the gypsum to wash down the rip lines into the subsoil.



Soil profiles showing increased root proliferation and biological activity within the slots where poultry manure was applied.

The 'modified' deep ripper that was used in small plot trials to incorporate organic substances to the subsoil at the time of deep ripping

f. Following any subsoil amelioration activities always undertake some form of controlled traffic to reduce the possibilities of recompaction.

Raised bed farmers in south-west Victoria have already achieved an improved rooting depth with the alleviation of waterlogging and improvements in soil structure. They also realise that even with the current opportunities for improved agronomy (eg. canopy management) on beds they are still not achieving yields that are close to the region's potential. The next stage of yield enhancement will include the modification of subsoil structure that can provide more PAW at depth to support crops through grain filling. This will improve the harvest index of the crop and potentially the grain size, which means a greater yield of grain and a reduced yield of straw. These subsoil improvement techniques, except for growing lucerne, are still in the experimental stage, but farmers may wish to consider trying one, or a combination, of the above suggestions on their paddocks while trying to raise the harvest index of their crops. For further soil-specific guidelines you may wish to contact SFS or the Department of Primary Industries.

For further details

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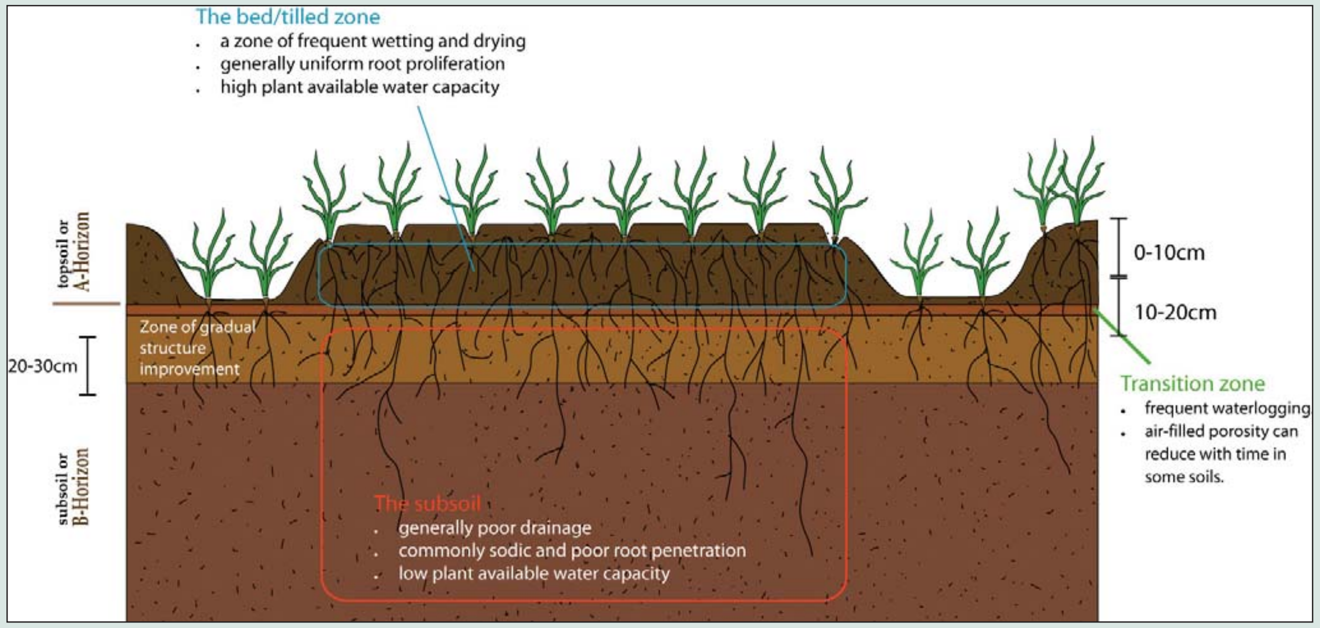

It has also been observed that although the soil structure at depth under beds is improving, there is often a problem zone under the bed at the same depth as the furrows (see diagram). Initially following the tillage undertaken when the beds are formed, aeration and conductivity is increased at this depth. However, if water is allowed to sit in the furrows for extended periods, some of those initial benefits to the soil in the beds appear to reverse. The saturation of this band of soil can lead to lack of oxygen, which slows biological activity. The problem is further exacerbated in dispersive soils leading to a decline in macro-porosity, which means there are less large pores to move water rapidly and provide oxygen for root respiration.

This work has led us to the identification of two major problem zones under raised beds.

(a) The Subsoil: the dense and large structural units of soil at depth which generally provide little access to water and nutrients to crops growing on beds

(b) Transition Zone: a shallower zone, occurring around furrow depth, which interferes with the connectivity between the topsoil on beds and the subsoil

Grazed lucerne pastures on raised beds

Intact soil core taken from 80cm depth in a 4-year lucerne paddock showing the intensity of cracking

Lucerne in the farming system

The use of deep-rooted lucerne has been successful in south-west Victoria in addressing the subsoil issue. This effect is often referred to as biological ripping or using lucerne as a primer crop. In our work the PAW capacity of a Vertosol (cracking clay) soil increased by approximately 25% following a 5-year lucerne phase compared to a system of continuous cropping. This increase appeared to have been caused by,

i. intense drying processes at depth causing large cracks in the soil
ii. increased root proliferation by lucerne within the large structural units of soil which, in time, become pathways for the roots of following crops and
iii. improvements to pore structure within the otherwise dense subsoil due to the creation of 'biopores'.

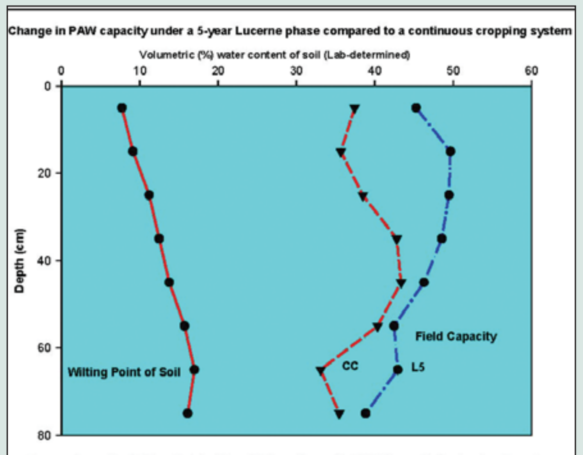

Figure shows the Wilting Point of the Soil together with Field Capacity for two treatments compared, i.e. Continuous Cropping (CC) and 5-year Lucerne phase on raised beds of similar age. After the Lucerne phase, the PAW capacity of soil (L5) increased.

Proliferation of lucerne roots in large structural units of soil at depth causing cracking & creating biopores.

Paint percolation study showing friable topsoil overlying the heavy clay, where the paint simply followed preferential pathways (cracks).

Lucerne roots take up more soil water at depth than those of annual crops, and this may be the cause of the greater cracking and opening-up of the dense subsoils. However the crop immediately following lucerne in the farming system can then be affected by inadequate soil water at depth. In July 2003 we measured 64mm of PAW to a depth of 80cm in a wheat crop following lucerne that had been removed in April, compared to 114mm in a wheat crop following canola in a continuous cropping system. This resulted in the wheat following lucerne yielding only 4 t/ha compared to 5 t/ha of wheat following the canola. The crop following lucerne appeared to be affected by water shortage during critical periods of grain development.

Similar observations have been reported from other cropping regions in Australia. However, the long-term advantages of a lucerne phase, which may last for several years, appear to outweigh any short-term disadvantages to the first crop; as well, the potential problem of a very dry subsoil in the first year after lucerne can be reduced by early removal of the lucerne in late spring rather than in the autumn prior to cropping. Despite the cracking and the resulting improvements in porosity in the subsoil during the lucerne phase, soil compaction near the surface due to grazing animals can still become a serious issue, particularly in the last summer prior to removal of lucerne. The use of higher stocking rates to use up the summer growth could, depending on the amount of summer rainfall and the condition of the surface soil, increase soil compaction closer to the surface. Some action must be taken to remove such compaction prior to sowing the next crop.

Slotting the soil with a slurry of poultry manure. Picture shows the laborious calibration operation.

Improving the connectivity between topsoil and subsoil

This lack of connectivity (transition zone) appears to be a result of a loss of air-filled porosity (large pores) in the subsoil in the transition zone. It may be possible to improve this by the incorporation of poultry manure and/or other porous substances such as wool scour waste or rice hull into the subsoil. Over the last three years, SFS has been conducting trials in south-west Victoria on slotting the soil with poultry manure and wool scour waste. The results were encouraging with most treatments giving better yields than the control. If sodicity, acidity or a lack of root proliferation are issues in the subsoil, the same methods could be used to add gypsum, lime or phosphorus fertiliser. The economics of these operations need to be considered. In 2004, we also followed a mechanical approach where we attempted to use a slurry of poultry manure in a slot that was created behind the tine of a deep ripper. These treatments have clearly indicated the qualitative differences that have been brought about in the proliferation of roots and increased biological activity in the subsoil. However, as yet there have been no statistically significant yield responses and this is thought to be the result of sub-optimal rainfall conditions in recent years.

More recently we have modified a deep ripper to combine the operations of ripping the heavy-clay subsoil to a depth of 40cm and dropping the organic matter around the 20cm depth where lack of porosity appears to be a problem. Some of this material will remain in the transition zone while some will move down to depth. We expect that the organic matter will gradually break down, improve the organic carbon content in the soil profile, and enhance both soil macro-porosity and storage of PAW. Stubble retention will also help to increase soil organic matter and may achieve the same outcome in the long-term. While crops on raised beds and controlled traffic systems are producing heavier top growth (biomass) compared to crops grown on flat paddocks, the conversion of that biomass to grain has been less than optimal. This also leaves heavy stubble loads on the ground after harvest. We recognise that dense and structure-less subsoils contribute to this less than ideal situation. It is hoped that the proliferation of lucerne roots will help produce enough organic matter connection in the soil at the interface of the topsoil and subsoil for these pathways to remain into the cropping phase. To further enhance the soil structural benefits of lucerne other management options can also be considered.