Managing Hostile Subsoils: What are the options?

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Summary

Hostile subsoils can significantly constrain crop growth and water use in the Mallee and Wimmera. Although the subsoil constraints are effectively fixed, the impact they have on grain yields can vary markedly with crop type and seasonal conditions (particularly the pattern of rainfall). Electromagnetic survey (EM) techniques offer the potential to assess the distribution and extent of subsoil constraints within a paddock. Management options however are currently limited and the most financially viable strategy may be to 'live with the problem' where inputs such as N fertiliser are limited and crop selection restricted to more tolerant types and varieties.

Background

Many of the alkaline and neutral soils of Victoria and South Australia possess a range of physical and chemical properties in the subsoil that are potentially limiting to crops. These limitations, commonly called subsoil constraints (SSC's) include factors such as primary salinity, boron, and sodicity. Research near Birchip (Nuttall et al. 2002) has shown that SSC's can reduce grain yields of crops such as wheat by more than a third of the water-limited yield potential in some seasons. However, anecdotal evidence suggest that some crops, such as lentils, may be even more sensitive to SSC's than cereals so the yield impacts may be even greater than first thought.

A large team, comprising members from DPI Victoria, BCG, SARDI and the University of Adelaide, with support from the GRDC, commenced a project in 2003 to assist grain growers to improve the profitability of cropping on soils with SSC's in both South Australia and Victoria. The project aims to survey the extent and impact of SSC's on different crops, assist grain growers to recognise whether they have SSC's on their particular property and, most importantly assess and demonstrate what options are available to allow them to economically manage these constraints. This paper focuses on some key results from the Victorian component of the project.

Methods

Twelve farmer paddocks, representing a range of soil types and crops from the Wimmera/Bordertown and southern Mallee regions have been monitored since 2003. Each season, crop growth (dry matter, grain yield and quality), soil mineral N and water extraction is measured at 10 fixed points (50 m spacing) within each paddock and related to a range of soil physical and chemical properties e.g.pH, sodicity and EC.

Results

In 2004, 11 farmer paddocks were monitored, consisting of 5 sown to wheat, 5 to barley and 1 to lentil (Table 1). Low rainfall up to anthesis and during early grain fill produced low yielding crop across the Wimmera and southern Mallee. Irrespective of a poor growing season large intra-site variation in crop yield still existed. For example, at Nhill, the paddock averaged 1.3 t grain/ha for wheat but yields ranged from 0.5 to 2.8 t/ha, with a similar large range in quality being recorded. This data will be pooled to allow the development of critical values for various soil properties such as salinity and boron for the range of crops grown throughout the Mallee and Wimmera.

Table 1: Mean response of crops monitored in farmer paddocks in 2004. (HI: harvest index; 1000-gw: 1000 grain weight (g); and screenings). Values separated by a dash define range of values within paddock.

Crop	Site	Maturity			
2004		Yield (t/ha)	HI	1000_gw	Screenings (%)
Wheat	Birchip	**0.7**	0.25	38	9.9
		0.4-1.0	*0.15-0.29*	*34-40*	*6.4-15*
	Birchip	**1.3**	0.36	32	3.7
		0.8-2.1	*0.31-0.41*	*29-35*	*2.5-5.0*
	Brim	**1.1**	0.23	32	6.1
		0.6-2.3	*0.13-0.36*	*26-40*	*1.9-11.3*
	Brim	**0.8**	0.26	24	13.9
		0.5-1.2	*0.19-0.36*	*20-29*	*6.1-26.3*
	Nhill	**1.3**	0.24	30	8.1
		0.5-2.8	*0.11-0.35*	*26-34*	*5.5-12.3*
Barley	Birchip	**0.5**	0.24	24	1.0
		0.2-0.8	*0.11-0.39*	*22-28*	*0-4.7*
	Donald	**1.2**	0.45	34	52.1
		0.5-2.3	*0.40-0.47*	*30-38*	*26.7-89.3*
	Nhill	**0.8**	0.17	33	12.8
		0.1-1.4	*0.03-0.36*	*26-37*	*0-40.9*
	Rupanyup	**1.7**	0.36	25	0.5
		1.4-2.0	*0.29-0.40*	*23-28*	*0.2-1.0*
	Warracknabeal	**1.2**	0.34	29	8.8
		0.8-1.5	*0.23-0.38*	*26-31*	*2.1-18.7*
Lentil	Jung	**0.7**	0.32	41	n/a
		0.4-1.0	*0.19-0.41*	*33-45*	n/a

The large variation in grain yield within different parts of a paddock corresponded to marked differences in relative yield for different crops/seasons. For example, at Golder's (Brim), chickpeas were low yielding (0.9 t/ha) at point 3 whereas at point 4 (50 m away), they yielded 1.0t/ha in 2003 (Figure 1). This pattern in yield response changed significantly in the following year with wheat yielding 0.75t/ha at Point 3 but 2.3 t/ha at Point 4. Similarly there was a large variation in the grain yield of field peas in 2005 that varied in a relative manner from crops in the previous two years.

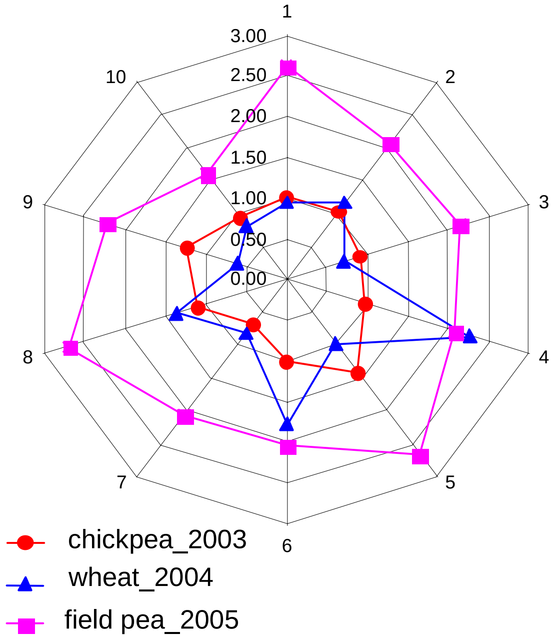

Figure 1: Intra-paddock variation in crop yield (t/ha) at Golder (Brim) for chickpea (2003), wheat (2004) and peas (2005).

Soil water extraction

Part of the spatial variation in grain yields observed within a paddock and between different crops in different years can be explained by seasonal rainfall patterns and the subsequent extraction of soil water by crops. For example, at Golder's (Brim) chickpea extracted water to a depth of 40 cm after a dry finish in 2003 (Figure 2). In contrast, wheat grown in 2004 extracted water to 60 cm by anthesis, however, high rainfall around crop maturity caused recharging of the soil profile to a depth of 40 cm. For peas, water extraction in 2005 appeared restricted to 20 cm.

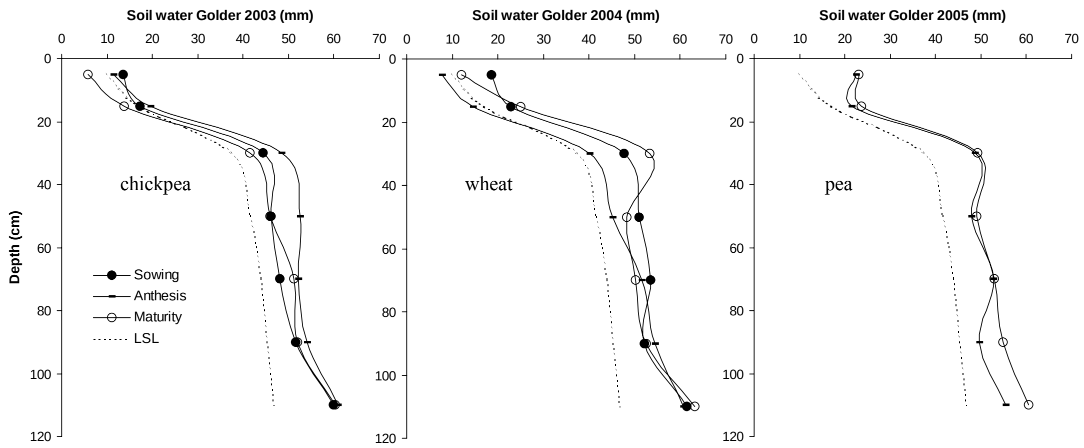

Figure 2: Soil water extraction patterns under 3 crops over consecutive years in a single paddock at Golders, Brim.

One difficulty farmers face when trying to manage the spatial variation occurring in grain yields as a result of subsoil constraints is having access to a rapid and relative cheap method to measure these soil constraints. Electromagnetic (EM) survey of the sites were taken at sowing and crop maturity (in collaboration with J McIntyre, DPI using NHT funding) to test the relationship between EM, subsoil constraints and crop growth (Figure 3). EM survey data at sowing is believed to be strongly correlated with profile salinity, whereas at crop maturity it is related to soil water remaining in the profile, thus indicative of crop water extraction across the paddock.

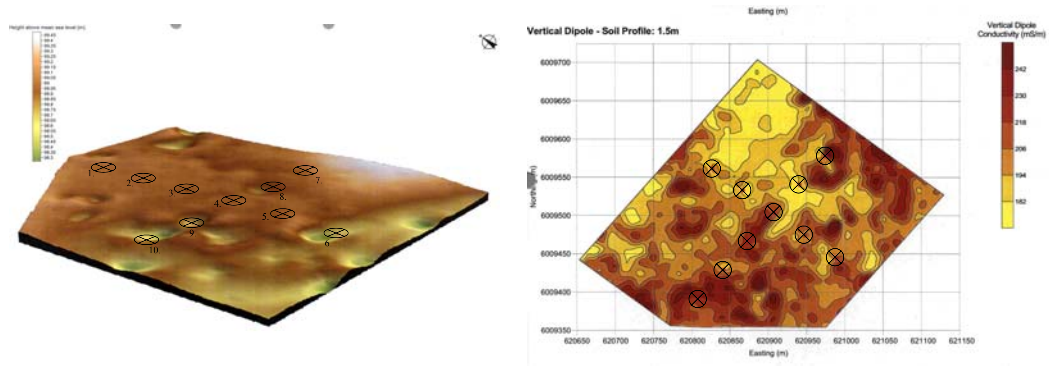

Figure 3: Electromagnetic survey of Golders (Brim) survey site in April 2005.

Interpretation

Hostile subsoils reduce grain yields primarily through restrictions to root growth and thus constraints to crop water use. Different crops can vary significantly in the relative impact of various subsoil constraints – for example pulses such as chickpeas are much less tolerant to salinity and boron compared to wheat. However the impact of subsoil constraints will also depend on the seasonal conditions. In seasons where there are regular rainfall events during spring (grain fill), crops are much less reliant on subsoil water and the negative impact of any subsoil constraints present is reduced. Techniques such as EM survey, when used in conjunction with appropriate soil analyses, offer considerable promise in identifying the extent and pattern of subsoil constraints within a paddock. However the major challenge for farmers is what to do if they have severe subsoil constraints. Many amelioration techniques eg. deep ripping, are unlikely to be effective or financially viable for region such as the Mallee or Wimmera, especially if subsoils are saline. In the longer term the development of new crop varieties with tolerances to constraints such as salinity and boron offer considerable promise. However, in the interim, the best management strategy available to farmers may be to 'live with the problem'. This strategy requires targeted selection of crop type (eg. cereals rather than lentils) and reducing variable inputs such N fertilisers, where severe subsoil constraints exist, so as to maximise profits rather than trying to maximise grain yields.

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