

THE SUB SOIL – ANALYSIS AND INTERPRETATION

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The subsoil

- Below 10 cm
- In top 10 cm – interest in managing fertility, soil acidity and sodicity
- In the subsoil – mostly concentrate on longer term management *and* how our knowledge of sub soil conditions affects management decisions

The subsoil

- Depth? Our interest as far down as (pasture) roots go
- Can be metres for Lucerne and phalaris, top 60 cm for sub clover
- Our practical approach is to measure 0-10 cm, 10-20 cm, 20-40 cm and 40-60 cm (not ideal)
- Cost is a consideration!



1



2



3

Sampling subsoil

- Variation presents difficulties
- Need to compromise – a few samples and accepting that there will be considerable “error” in the outcome
- Can be sensible – ie choose major soil type in the paddock
- Rocks!

What to analyse?

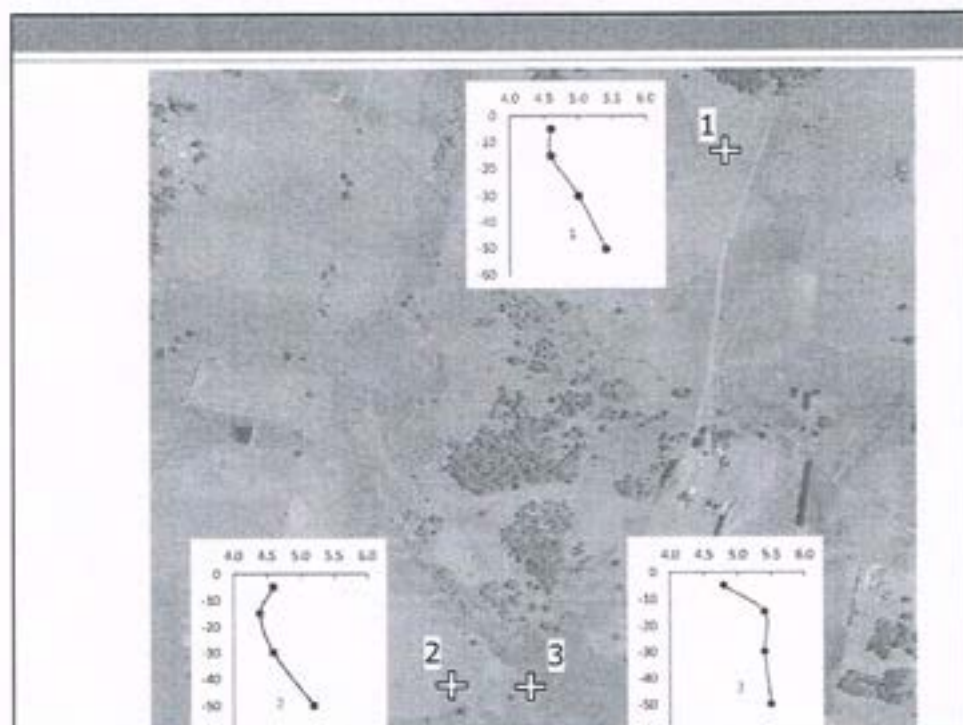
- Soil Acidity
 - Soil pH - in CaCl_2 solution for interpretation (often pH in water also provided)
 - Why? Consider history – pasture systems acidify soils
 - Product removal
 - Increase in organic matter
 - Nitrate leaching
 - Not just the surface layer affected
 - Some evidence.....from studies in this region.....

Acidification - Historical

- Southern Tablelands of NSW
- Paddocks originally sampled in 1952/3 then sampled in 1977/78. Also comparisons of "virgin" soil versus soils under sub clover + super
- Two studies:
 - Williams 1980 – AJEAAH 20: 561-567
 - Bromfield et al. 1983 AJEAAH, 23 : 181 – 191
- Soil pH measured in water – subtract 0.8-1.0 to get the level in a CaCl_2 solution

Soil Acidity

- As pH declines – available Aluminium (and Manganese) increase – toxic to plants, more of this later
- What does subsoil acidity look like on this property?
- Three locations – soil pH plotted versus depth



Exchangeable Cations

- Soil pH alone doesn't tell us all we need to know
- This is a measure of the soil's capacity to hold exchangeable cations (positively charged ions) and is calculated from the exchangeable levels of calcium (Ca^{2+}), magnesium (Mg^{2+}), aluminium (Al^{3+}), sodium (Na^+) and potassium (K^+).
- Aluminium toxicity calculated from aluminium as a % of CEC ("Aluminium Saturation") – hence we need to order analyses of pH and cation exchange
- Species differ in response to Aluminium – from very susceptible to highly tolerant....

Table 4. Aluminium sensitivity (tolerance) of some crop and pasture plants.

Highly sensitive	Durum wheat, most barley cultivars, faba beans, lentils, chickpeas, lucerne, medics, Strawberry, Berseem and Persian clovers, Buffel grass, tall wheatgrass
Sensitive	Cunningham & Lang wheat, Canola, Yamba barley, albus lupins, red grass (Wagga), wallaby grass (<i>D. linkii</i>), phalaris, red clover, Balansa clover, Caucasian and Kenya white clovers
Tolerant	Whistler, Sunstate & Diamondbird wheats, annual & perennial rye-grass, tall fescue, Haifa white and subterranean clovers, chicory
Highly tolerant	Narrow leaf lupins, oats, triticale, cereal rye, cocksfoot, kikuyu, paspalum, yellow & slender vetch, Maku lotus, common couch, Consol love grass

These are only examples. For the current information on the tolerance of current varieties of winter crops to soil acidity see the Winter crop variety sowing guide published annually by NSW Department of Primary Industries.

Table 5. Critical concentrations of calcium chloride extractable aluminium

Aluminium tolerance of plants (Table 4)	Critical levels Al_{ex} mg/L	Equivalent % Al_{ex} for soils at different electrical conductivities (EC 1:5 dS/m)		
		Low EC < 0.07	Med. EC 0.07-0.23	High EC > 0.23
Highly sensitive	0.1-0.4	9-16	2-8	0.5-2
Sensitive	0.5-0.8	17-20	9-12	3-6
Tolerant	0.9-1.6	21-32	13-21	7-10
Highly tolerant	1.7-2.7	33-43	22-30	11-16

Note – EC – electrical conductivity usually measured alongside pH

NSW DPI Agrisc. Soil Acidity and Liming, 2006

Cation exchange – our three samples

Name	Depth	pH (CaCl ₂)	Conductivity dS/m	Exchangeable Cations (meq/100 ml)							%Cations	
				Al	Ca	Mg	K	Na	Total	Al	Na	
Cawthorne 1	0-10	4.6	0.117	0.7	8.08	1.78	1.93	0.04	12.5	5.6	0.3	
Cawthorne 1	10-20	4.8	0.047	0.79	7.55	1.17	1.53	0.04	11.1	7.1	0.4	
Cawthorne 1	20-40	5	0.037	0.22	7.38	1.45	1.26	0.04	10.4	2.1	0.4	
Cawthorne 1	40-60	5.4	0.042	0.2	7.72	1.92	0.82	0.04	10.7	1.9	0.4	
Cawthorne 2	0-10	4.6	0.09	0.74	2.99	0.45	0.29	0.16	4.63	16	3.5	
Cawthorne 2	10-20	4.4	0.021	1.42	0.83	0.24	0.09	0.06	2.64	53.8	2.3	
Cawthorne 2	20-40	4.6	0.014	0.46	2.97	1.1	0.12	0.08	4.73	9.7	1.7	
Cawthorne 2	40-60	5.2	0.015	0.08	4.24	2.18	0.16	0.1	6.76	1.2	1.5	
Cawthorne 3	0-10	4.8	0.051	0.27	2.59	1.31	0.35	0.3	4.82	5.6	6.2	
Cawthorne 3	10-20	5.4	0.023	0.11	3.26	4.1	0.15	0.45	8.07	1.4	5.6	
Cawthorne 3	20-40	5.4	0.019	0.12	2.89	3.85	0.14	0.39	7.39	1.6	5.3	
Cawthorne 3	40-60	5.5	0.019	0.1	2.67	3.36	0.13	0.28	6.54	1.5	4.3	

Soil pH and Aluminium Implications

- Liming? Slow at depth – slow but eventually effective
 - Selection of appropriate species – would you sow Lucerne into soil from paddock 2?
- Another example from Merrill – Far West

Name	Depth	Conductivity	pH (CaCl2)	Exchangeable Cations (meq/100 ml)						%Cations	
				Al	Ca	Mg	K	Na	Total	Al	Na
Far West	0-10	0.026	4.2	0.89	1.05	0.23	0.18	0.02	2.37	37.6	0.8
Far West	10-20	0.017	4.4	0.57	0.99	0.17	0.07	0.02	1.82	31.3	1.1
Far West	20-40	0.016	4.4	0.58	0.73	0.54	0.08	0.06	1.97	28.4	3
Far West	40-60	0.021	4.1	1.95	1.3	2.72	0.13	0.25	6.35	30.7	3.9

Increase in pH at depth – 0.04 pH units/year

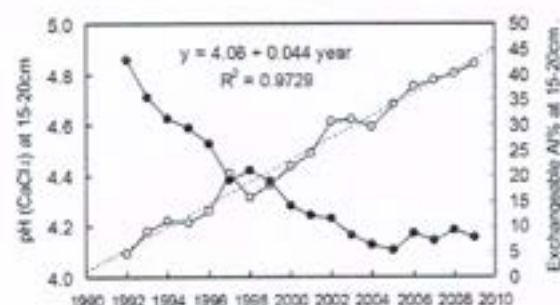


Figure 7. Long-term trends of subsurface soil pH_{Ca} (○) and percentage of exchangeable aluminium (●) at 15-20 cm on the limed treatments in 1992-2009.

L. Conyers & C. Cullis (2010) Long-term liming ameliorates subsoil acidity in high rainfall zone in south eastern Australia. 18th World Congress of Soil Science

Deep soils analyses and sodicity

- Soil is sodic – ie. exchangeable sodium is >5% of the CEC
- What does this mean? Sodium levels high enough to affect soil structure – the soil doesn't "hang together"

Depth cm	Cond. dS/m	pH (CaCl ₂)	Exchangeable Cations (cmol/kg)					Total (cmol/kg)	Al %	Na %
			Al	Ca	Mg	K	Na			
0-10	0.052	5.1	0.09	3.06	1.1	0.27	0.17	4.69	1.9	3.6
10-20	0.028	5.8	0.07	2.54	2.2	0.17	0.37	5.35	1.3	6.9
20-40	0.056	5.8	0.09	4.35	6.32	0.35	1.32	12.43	0.7	10.6
40-60	0.115	6.3	0.09	4.9	7.64	0.33	2.36	15.32	0.6	15.4
60-80	0.223	7	0.05	4.17	7.28	0.31	3.26	15.07	0.3	21.6

- At depth what can be done – advice from Mark Conyers
DPI – increase in organic matter, increase soil pH
- Gypsum....20 t required to lower exch Na to 5 %!!

Low CEC....implications...

- Far West at Merrill again

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- What does this mean – low charge....poor structure?

Summary

- Worth knowing about the sub soil
- pH, conductivity and exchangeable cations are the main measurements
- From there can calculate % Aluminium, % Sodium
- Management decisions include:
 - Pasture species selection
 - Liming
 - Investment – Buying or investing in hostile sub soils?