MURRAY DAIRY - AUTUMN START-UP WORKSHOPS.

Technical Note: CONSOLIDATED, COMPACTED OR BLEACHED A2 SUBSURFACE HORIZONS.

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Description of the issue and importance: Consolidated, compacted and dense subsurface horizons can restrict the movement of water, air and plant roots into and out of subsoil horizons. Under such conditions there is often limited pore space, moisture movement and air for roots to access and grow. It is initially important to determine if the subsurface layer impeding growth exhibits a similar texture to the A_1 horizon. If so, this usually indicates that the layer is an A_2 horizon and the restrictive layer is likely to be consolidated topsoil, rather than subsoil.

Primary mechanisms contributing to the development of such layers include:

- Deep A horizon topsoil of more than 12cm, overlying low permeability subsoil clay. As topsoil remains saturated after subsoils reach field capacity, the lower part of the A horizon becomes saturated, consolidated and often bleached from waterlogging.
- Leaching of bases such as calcium, magnesium, sodium, potassium and aluminium from the lower part of the A horizon, caused by cycles of seasonal saturation and slow leaching, resulting in bleaching of the layer.
- Slaking of aggregates resulting from a lack of organic matter and limited plant root mass, causing consolidation.
- Dispersion of the clay fraction, causing suspension of clay fines and consolidation.
- Fluffing of the A_1 horizon from tillage equipment, where the clay fraction leaches below the tilth zone and forms a plough pan.
- Subsurface compaction from cattle in wet conditions
- Subsurface compaction from vehicle traffic under wet conditions

Problem Identification: Methods for identification and indicators of such conditions can be determined from both visual and measured methods. These include:

1. Bulk density testing of each layer, identifying material of high density in the A_2 horizon. Details on soil density are provided in Tables 3 and 4.

2. Visual identification of poorly structured layers, either:
    - Massive (structure less)
    - Platy (horizontal, plate-like layers

3. Grey or bleached conditions between the A_1 and B_1 horizons

4. Poor plant rooting or a plant root score less than that of the layer above and below

5. Grey, 'spew' layers observed when machines are bogged or when paddocks receive traffic when wet

6. Sodic or dispersive conditions within the problem layer or the B_1 horizon subsoil clay

A hand penetrometer generally fails to aid characterisation of the restrictive layer. When wet, there is minimal resistance to penetration from a reduction in soil strength. When dry, there is high level of resistance to penetration, however cracking may improve soil structure.

<u>Visual Assessment:</u> Figure 1 is an example of a Goulburn Loam soil profile from the region evincing a thin, bleached A_2 horizon layer. The A horizons are a homogenous texture, however the structure of the material within the A_1 and A_2 horizon varies significantly. Figure 1 shows a higher level of tilth and organic matter close to the surface. The A_2 horizon is structure-less and contains limited plant roots.

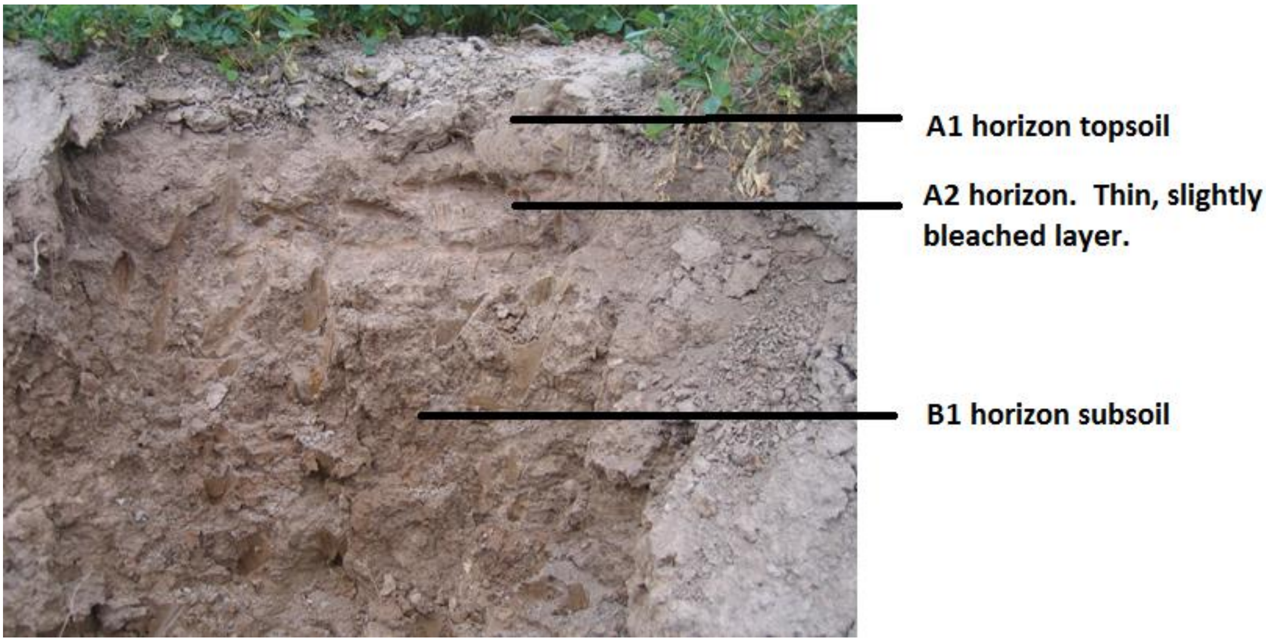

Figure 1. Example Goulburn Loam soil profile.

Table 1 is a guide to the interpretation of soil bulk density and the impact of levels registered on plant growth for a range of soil examples. Data is compiled from a range of sources including Brady and Weil (2008, p. 157) and Charman and Murphy (1991, p. 234-237), McKenzie *et al* (2004), Davies and Lacey (2011) and others.

Table 1. Interpretation guide for soil bulk density results.

Bulk Density (tonnes/m^3)	Interpretation	Impact on Root Growth	Example Soils
<0.8	Extremely low.	Low-nil. Possible drought effects from good drainage and evaporation	Silts and peats.
0.8-0.9	Very low	Nil. Could cause drought effects from drainage and evaporation.	Self-mulching clay or topsoil.
1.0-1.1	Low	Nil. Optimal for most agricultural and horticultural soils. Soil density should not restrict root growth.	Self-mulching clay or topsoil. Loose sand with organic matter Ameliorated clays and loams
1.1-1.3	Acceptable	Low-Moderate. Generally, not an impediment to root growth on clay-loam soils.	Ameliorated clays and loams. Well-structured clays. Compacted sandy loams
1.4-1.5	High	Moderate-high. Will restrict root development of most crops. Physical and chemical amelioration required. NOT ALWAYS RELEVANT FOR CRACKING CLAY SUBSOILS.	Clay loams high in Na and Mg suffering consolidation or compaction. Typical of heavy clays with reasonable structure.
1.6-1.8	Very high.	High restriction to root development. Soil requires shattering to reduce aggregate size and to increase root mass. Chemical stabilisation also required.	Poorly structured clays. Highly compacted sands and clay loams.
<1.8	Extreme.	Indicative of an impermeable condition.	Compacted soils.

Management options: Options for correction of consolidated, compacted, dense or bleached subsurface layers are listed below. These are directed towards improving soil structure and depth of the A horizon to secure higher available water and nutrient levels for pastures or crops. Where the problems are below 300mm of depth, options available are limited.

Where soil physical amelioration by ripping is required, care must be exercised to ensure that when the layer is fractured, aggregates are stabilised. This can occur if a combination of processes occurs simultaneously, listed below.

Ripping and shattering can:

- Improve soil structural conditions
- Mix A_1 horizon topsoil throughout the problem layer
- Mix organic matter from crop residues and plant roots
- Mix soil ameliorants including gypsum, lime, manure, straw and compost
- Mix fertilizers and crop nutrients deeper in the profile.

Bleached layers should not be raised and exposed on the soil surface. Cloddy material remaining after ripping may require treatment to secure a seed bed. From experience, the option of doing nothing generally yields a poor outcome. The primary role of soil physical amelioration in these situations is to break the back of the problem.