Hi-Grain UPDATE

Research to profit higher-rainfall temperate zone graingrowers

Research News

September 2004

SOIL STRUCTURE DIFFERENCES UNDER RAISED BEDS

Background

Raised beds have been researched and adopted as a drainage method in Victoria since 1996. During the 2003-growing season almost 30,000 hectares of raised beds were cropped in western Victoria. Improved crop yield experienced by farmers using this method has primarily been attributed to the alleviation of water-logging. However, along with the alleviation of waterlogging, raised beds appear to set in motion a series of changes within the soil that contribute to long-term sustainability of cropping systems and improvements in crop yield, particularly in sub-optimal rainfall years.

In 2002, a 'drought' year for Victoria, raised bed farmers reported the lowest yield reductions; in fact many raised bed farmers achieved average to above average yield despite the poor rainfall distribution. Improved soil structure experienced by crops sown on raised beds is a major contributory factor to this improved crop performance.

Evidence from research

The dominant soils

A long-term experiment commenced in 1998 at Gnarwarre near Geelong in south-west Victoria to assess the impact of raised beds on soil structure. Selected farming systems were established on two soil types that are representative of the soils in the region. They are:

(1) Black, self-mulching cracking clay (BCC)
(2) Mottled grey-brown clay (MGC)

Grains Research & Development Corporation
SOUTHERN FARMING SYSTEMS
State Government Victoria Department of Primary Industries

The higher PAW capacity results in more water being taken into and held in the soil after rain. The higher porosity allows the water to be taken into the soil at an increased rate, thus delaying the onset of a perched water table under intense rainfall events and retaining more useful water in the soil. Crops with more water at critical stages of yield development means improved water use efficiency and provides scope for further improvement in yield and yield stability.

Friable deep soil from raised beds (Left) compared to a wet, waterlogged soil from a flat crop (Right)

The other differences observed in both soil types over the years, along with their practical implications for cropping on raised beds, are:

Roots on raised beds BCC soil *Roots on Flat BCC soil*

a. The prevention of waterlogging in both soil types over the years led to an increase in the depth of aggregates, probably due to better wetting and drying of the root zone

b. The friability of soils improved on raised beds, resulting in:
- better environment for root growth and proliferation
- improved seed-soil contact and uniform crop establishment
- improved workability of soil: After three years of raised bed cropping, both soils tolerate a higher water content before they begin to lose friability and cause wheel slippage when machinery is used. This should provide farmers with a greater window of opportunity in sowing and other operations compared to flat cropping

c. Damage to soil structure by wet weather grazing can be minimised through tactical grazing. In both soil types studied it proved possible to direct seed a crop on beds following grazed pastures without the need for any re-forming of beds

Work continues to monitor further soil structure changes at depth.

Further reading:

Southern Farming Systems (2000). Raised beds and controlled traffic cropping: An exciting concept being developed to overcome waterlogging and to improve soil structure. Eds. Bruce Wightman and Peter Kealy. Southern Farming Systems.

Cotching, WE and Dean, GJ (2001). Soil properties under raised bed farming systems in Tasmania. Proceedings of the 10th Australian Agronomy Conference, Hobart, 2001.

Peries et.al., (2004). Raised bed cropping in southern Victoria – A snapshot of a productive and sustainable option for waterlogging prone soils. Proceedings of the 12th Australian Agronomy Conference, Brisbane.

For further details

Contact the Project Supervisor at Southern Farming Systems,
Colin Hacking *on (03) 5229 0566*

or Project Scientist,
Renick Peries *on (03) 5226 4827,*
renick.peries@dpi.vic.gov.au

or Regional Agronomist,
Bruce Wightman *on (03) 5226 4715,*
bruce.wightman@dpi.vic.gov.au

Sheep grazing raised beds

Both these soils are high in clays, which swell when wet and crack when dry. They have distinct characteristics that lead to differences in behaviour in response to both bedding and waterlogging. Differences in plant available water (PAW), soil aeration (porosity) and soil bulk density (BD) impact on the performance of crops growing on these soils.

The PAW capacity of a soil is defined as the amount of water that can be most easily accessed by crop plants and held within the small (micro) pores of the soil. It is that quantity of water held between the wilting point (WP - the lower level of PAW) and field capacity (FC - the upper level of PAW). The higher the content of clay in the soil, the higher the tension under which water is held to the soil particles. Such tightly held water is difficult for plants to access. Also, the higher the content of clay in the profile, the narrower the difference between wilting point and field capacity.

When the soil is saturated and the free water is drained off soil moisture will generally settle at field capacity and the soil will not be waterlogged. If the soil does not drain freely it will stay saturated and this will waterlog any crop that is growing in the paddock (Figures 1 and 2).

The bulk density of soil is defined as the weight of a unit volume of soil. It describes how the solid particles (clay, sand, silt etc.) and the air spaces are packed together to form soil aggregates. A very dense soil will have a high BD, and will essentially have low porosity.

Black, self-mulching cracking clay soil (BCC) (Figure 3)

- represent almost 10% of south-west Victoria cropping soils
- profile uniformly high in clay content throughout its depth (generally>40%)
- drainage is slow when wet
- when dry, intense cracks allow water to penetrate deeper into soil profile
- under dry and windy conditions the cracks can contribute to water loss
- plant available water (PAW) of 100-150mm to a depth of 1 metre

Mottled grey-brown clay soil (MGC) (Figure 4)

- behaviour represents >70% of cropping soils on the basalt plains in south-west Victoria
- mottling effect in the subsoil indicates long-term waterlogging (note: mottled clay soils are commonly associated with duplex soils and sodic subsoils which have poor drainage)
- long-term soil compaction in pasture by livestock and uncontrolled traffic increases the soils susceptibility to waterlogging
- high clay content layers impede water penetration to the subsoil which results in a 'perched water table' in the topsoil above subsoil
- plant available water (PAW) capacity marginally lower compared to BCC (note: in the typical duplex and sodic soils that are extensively cropped in the region this could be around 75 to 100mm)
- also prone to cracking and self-mulching but to a lesser extent than the BCC

Figure 1 & 2
A waterlogging paddock before and after bed forming

Figure 3
The black cracking clay

Figure 4
The mottled grey clay

When raised beds are installed on these soils, water drains off easily into the furrows due to the porous and open nature of the soil in the beds (Figure 2). This prevents waterlogging where excess water saturates the root zones of the crop plants. After many cycles of wetting and drying, the soil has the ability to form aggregates on beds and this is aided by the lack of compaction on beds. Tractor wheels are confined to the furrows at all times.

Our research of 'systems on raised beds' was conducted with controlled traffic (CT) and minimum tillage. During all major field operations such as sowing, spraying, harvesting etc. the tractor wheels were confined to the furrows between the beds, thus minimising compaction compared to a flat pasture or flat cropping situation. Treatments also included two and four-year phases of grazed pasture on raised beds that were tactically grazed to avoid excessive compaction.

Results

Soil structure better under raised beds

Table 1 shows differences in soil bulk density and total porosity of the BCC and the MGC soils measured three years after the installation of beds. This comparison was made in 2002 and is between the flat pasture and raised beds that have had three years of planned rotations. Similar differences in soil BD and porosity between raised beds and the flat have been reported from work in Tasmania (Cotching and Dean, 2001).

Table 1. Soil bulk density and porosity differences on raised beds compared to flat pasture

Black cracking clay soil (BCC)				
Depth (cm)	**Soil BD gcm^{-3}**		**Porosity (%)**	
	Flat perennial pasture	Raised beds	Flat perennial pasture	Raised beds
0-10	1.4	1.1	50.8	58.7
10-20	1.4	1.2	50.0	55.9
20-30	1.6	1.3	43.7	53.1
30-40	1.7	1.4	37.9	51.3
Mottled grey-brown clay soil (MGC)				
0-10	1.5	1.4	46.6	50.2
10-20	1.6	1.5	43.6	47.0
20-30	1.7	1.5	38.4	43.6
30-40	1.6	1.5	40.4	44.4

Differences below depth of cultivation

Data shows that the MGC soil was denser than the BCC soil, but differences in soil BD and porosity were measured in both soils three years after the installation of the beds and the commencement of CT cropping. These differences account for an enhancement in the PAW capacity in the root zone of the soil - an 11% increase in the BCC and a 21% increase in the MGC (Graph 1), monitored to a depth of 40cm. Prior to bedding, the soil was cultivated to a depth of only 20cm, but after three years the observed differences extended below this depth. Graph 1 shows the difference in field capacity between the flat pasture and the raised beds: the soil on raised beds had greater soil water storage ability.