NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SOILpak – vegetable growers - Readers' Note

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PART C. VEGETABLE-GROWING LANDSCAPES

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Chapter C1. Sandhill soils

PURPOSE OF THIS CHAPTER

To outline the characteristics of sandhill soils

CHAPTER CONTENTS

- appearance
- topography and vegetation
- land-use limitations and soil problems

ASSOCIATED CHAPTERS

- Part C

SOIL GROUPINGS

The five main groupings of soils used in Part C of this manual are:

- sandhill soils (sandy soils)
- red brown earths (soils with a sandy loam – loam topsoil)
- transitional red brown earths (soils with a shallow loam – clay loam topsoil)
- alluvial soils
- self-mulching clays.

Many vegetable-producing soils, such as the soils of the Riverina Plain, are formed upon sediments from ancient rivers that once dominated the area, along with clay materials carried into the area by wind. These ancient rivers are often referred to as 'prior streams'.

As you move away from the prior stream towards the far flood plain:

- the surface loam horizon becomes thinner
- the surface soil becomes more clayey in texture
- the depth of the clay subsoil increases.

Vegetation may help in identifying the soil type, since soil types, vegetation and local topography are all related.

In reality, soil types usually change gradually with distance from the prior stream, not abruptly as could be inferred from below. This is the reason why it is sometimes difficult to place a soil into one of the types referred to in this section.

SANDHILL SOILS

- Sandhills occur close to prior streams, but prior streams may exist with no associated sandhills.
- Sandhill soils have a topsoil of loose sand greater than 15 cm deep.
- Deep sands have loose sand to a depth of 2 m or greater, with no obvious subsoil, or bleached layers.

- Shallow sands have a shallower topsoil overlying a clay subsoil. A bleached layer in the lower topsoil is usually present.

APPEARANCE

The variation of physical characteristics within the soil group 'sandhill soils' is large when compared with the other soil groups. The major criterion for inclusion in this soil group is a loose sandy topsoil not less than 15 cm deep.

Texture

The deep sands usually consist of loose sand to a depth of 2 m or more. In some areas numerous thin clay bands may be present in the deep sands. These clay bands are thought to originate from wind-blown clay materials. Bands of loam clay of varying thickness may develop in the soil due to leaching of clay materials out of the topsoil. The deep sand occurs in the more elevated areas of sandhill formations. No change in texture within the top 2 m is obvious in the deep sands. Towards the lower areas of sandhill formations, the depth of loose, sandy topsoil decreases and a relatively shallow clayey sand subsoil is present.

Colour

The colour of the sandy topsoil is generally brown to red brown, but shallow sands may be grey brown. The subsoils (where present) vary from red to yellow to grey. Yellow and grey are the most common colours in heavier, poorly drained subsoils.

PERCHED WATERTABLES

When subsoils are of low permeability, perched watertables may form above them. This is obvious when you are comparing soils from the higher elevated areas of a sandhill to the low areas around the fringe of the sandhill, since a bleached layer in the lower topsoils is more pronounced. Bleached layers are a sign of a perched watertable (usually caused by relatively impermeable subsoils) and are therefore more obvious where the subsoil is more clayey. The shallow sands will have a clay subsoil, overlain by a bleached layer of the lower topsoil.

TOPOGRAPHY AND ASSOCIATED VEGETATION

The presence of a clay subsoil can be related to the formation of the sandhill. Most sandhills formed when the wind blew sandy materials out of the prior-stream bed on to the surrounding soil, which was more clayey in texture. This previously exposed soil became the new subsoil. Where the sandhill is at its highest, the underlying clay may be at such a depth that it has no effect on plant growth in the soil above it.

Vegetation on sandhill soils is predominantly white cypress pine, with some grey box and yellow box towards the extremities of the sandhills.

LAND-USE LIMITATIONS AND SOIL PROBLEMS

Water management

- sandhills (especially deep sands) have a low water-holding capacity and poor nutrient retention

- sandhill soils are well drained, except where an impermeable clay or cemented layer is within the root zone.
- a bleached layer indicates periodic waterlogging caused by a perched watertable overlying an impermeable layer
- sandhills may be prone to erosion.

Sandhill soils contain very little clay and silt in their topsoils. In the deeper sandhill soils the topsoil extends beyond the root zone of most crop and pasture plants. Since the topsoils are predominately sand, of which a high proportion is coarse sand, the ability of the soils to store moisture for use of plants is very low. This means that particular attention must be paid to the irrigation frequency in an effort to keep plants supplied with water, without wasting water by allowing it to move out of the root zone. Therefore, frequent light irrigations are necessary.

Nutrient management

The nutrient supply also requires careful management. Nutrient storage in a soil is influenced mainly by finer particles such as clay and silt, along with organic matter. As all of these are in short supply in sandy soils (especially deep sands), nutrient shortfalls leading to decreased crop yield are likely. The ability of sandy soils to resist a change in pH, known as their buffering capacity, is low, so pH must be monitored carefully. Lime may need to be applied periodically, depending upon land management.

Some sandhill soils contain a loamy or clayey sand band (thin subsoil) in which clay and silt particles have accumulated. This zone will be advantageous to crop production if:

- the loamy/clayey band is reasonably permeable to water and air, and
- the loamy/clayey band is within the root zone of the crop.

This loamy or clayey band will increase the water-holding capacity and nutrient storage ability of the soil.

When a relatively impermeable clay subsoil is within the root zone, plant production may be impaired. This is mainly because perched watertables may form above the clay subsoil.

Soil erosion

Soil erosion is likely to be a major problem on sandhill soils, especially when cultivation leaves the soil bare, as in annual vegetable crop production such as potatoes. It is therefore important to maintain soil cover for as long as possible to reduce this risk.

Chapter C2. Red brown earths

PURPOSE OF THIS CHAPTER

To describe the characteristics of red brown earths

CHAPTER CONTENTS

- appearance
- topography and vegetation
- land-use limitations and soil problems

ASSOCIATED CHAPTERS

- Part C

RED BROWN EARTHS

- Red brown earth soils have a topsoil of sandy loam to light clay loam overlying a clay subsoil.
- The lighter (coarser) textured topsoil is between 10 and 40 cm thick and varies from red to grey brown.
- The lower topsoil is called the A2 horizon. This may be bleached. The subsoil varies from yellow to red to grey.

APPEARANCE

Texture

The red brown earth soils are of duplex nature, that is, they have a layer of sandy loam to light clay loam overlying a clay subsoil. The surface loam may vary in thickness from 10 to 50 cm. Subsoils are more crumbly and coarser in texture at depth compared with the overlying, uppermost part of the subsoil.

Colour

Colour varies from red brown to light grey brown on the surface. Clay subsoils may vary from yellow to red to grey. 'Mottled' subsoils are common. Mottled refers to a mix of colours in a patchy appearance. The lower part of the loam topsoil above the clay subsoil is called the A2 horizon, and may be of bleached, white appearance. Deeper subsoils are usually yellowish or olive brown, and sometimes grey.

Structure

The topsoil (often called the 'A horizon') of a red brown earth may set very hard with few cracks upon drying, showing very little structure. This feature is known as 'hardsetting'. It occurs frequently in soils that are high in fine sand and/or silt and low in organic matter. A hard surface layer up to 1 cm thick (known as a 'crust') may form in some soils for similar reasons. Despite this, many of these soils were favourably structured before excessive cultivation damaged their structure. In some instances, nearer to sandhills and prior streams, the topsoil may be sandy and loose. Clay subsoils (often called the 'B horizon') are of high clay content and often exhibit a coarse blocky to column-like structure.

PERCHED WATERTABLES

Waterlogging in these soils is usually caused by a perched watertable occuring directly above the subsoil during wet periods. Perched watertables are most likely where the subsoil is relatively impermeable to water (water moves through the subsoil very slowly). A bleached A2 horizon is a sign of periodic waterlogging.

TOPOGRAPHY AND ASSOCIATED VEGETATION

The natural vegetation most likely to be found on areas of red brown earths is the following:

- western grey box
- yellow box (in sandy, well-drained red brown earths)
- white cypress pine (on sandier red brown earths, usually in more elevated positions).

LAND USE LIMITATIONS AND SOIL PROBLEMS

Excessive cultivation may cause a decline in the structure of topsoils of red brown earths, resulting in poor plant growth.

Clay subsoils can be sodic and poorly structured.

Hardsetting

The topsoil of a red brown earth can be hardsetting. This condition can be aggravated by excessive cultivation. The topsoil in these soils is low in clay and largely reliant on organic matter to promote good structure. Excessive cultivation breaks down soil aggregates and lowers the organic matter content of soils, thereby damaging soil structure. A sub-angular blocky structure associated with hardsetting soils is widespread.

Structural instability and slaking

When the topsoils of red brown earths are structurally unstable, flood irrigation or heavy rainfall causes these soils to slake, forming microaggregates. Dispersion is likely if the soil is sodic and non-saline. Both dispersion and slaking will increase the soil bulk density, resulting in a number of problems for plant production:

- formation of a surface seal or crust, which reduces seedling emergence
- poor water infiltration, resulting in limited depth of wetting. This decreases plant growth, due to water shortages, if the irrigation frequency is not increased.

The subsoils (B horizons) are generally high in clay content and have a high bulk density, low permeability and high mechanical resistance to root growth. Therefore waterlogging, poor root growth and limited depth of wetting can occur in the subsoil of red brown earths. These problems are more likely when the subsoil is sodic.

Good soil management can improve the structure of the topsoil and the subsoil to allow better air and water movement and increased root growth. This may be achieved through such practices as:

- minimising cultivation, especially the use of disc implements
- increasing the organic matter content
- cultivating at appropriate soil moisture levels
- use of water application methods that wet soil slowly and hence reduce slaking, for example, micro-irrigation
- including perennial pastures in crop rotations.

Chapter C3. Transitional red brown earths

PURPOSE OF THIS CHAPTER

To describe the characteristics of transitional red brown earths

CHAPTER CONTENTS

- appearance
- topography and vegetation
- land-use limitations and soil problems

ASSOCIATED CHAPTERS

- Part C

TRANSITIONAL RED BROWN EARTHS

The problems with plant growth experienced in transitional red brown earths are similar to those seen with red brown earths. However, these problems are more likely in transitional red brown earths because of shallow topsoils and finer (more clayey) texture.

APPEARANCE

Transitional red brown earths differ from red brown earths in that they have:

- shallower, often more clayey topsoils
- more clayey, deeper subsoils.

Transitional red brown earths are a specific subgroup of red brown earth soils. The difference between transitional red brown earths and red brown earths is that transitional red brown earths have a shallow topsoil (A horizon) of 5 to 10 cm of clay loam, whereas red brown earths possess deeper A horizons (10 to 40 cm in depth), usually of lighter texture.

The colours of the topsoil and subsoil are much the same as those described for red brown earths; red brown is the most common colour.

The deep subsoil of the transitional red brown earth is likely to be more clayey than that of a red brown earth, since transitional red brown earth soils are formed on finer sediments than red brown earths. For the same reason, topsoils are shallower and of more clayey texture than red brown earths.

TOPOGRAPHY AND ASSOCIATED VEGETATION

Transitional red brown earths are usually found near flood plains. However, transitional red brown earths also occur in association with self-mulching soils in gilgais or small mounding complexes. The transitional red brown earths are located on the shelf (slightly depressed areas) of the gilgai complex.

The natural vegetation most likely to be found on transitional red brown earths is:

- boree
- western grey box (in better-drained transitional red brown earths)
- black box (in poorly drained areas, often in a gilgai formation).

LAND-USE LIMITATIONS AND SOIL PROBLEMS

Most of the same physical restrictions to plant growth found in red brown earths are likely to be a problem in transitional red brown earths. Problems are:

- low subsoil permeability
- high subsoil bulk density
- high mechanical resistance to root growth
- low air-fill porosity (lower amount of pore space in which air and water can move)
- hardsetting topsoils.

The topsoils of transitional red brown earths are shallower and of finer texture than those of red brown earths. Waterlogging is more likely in transitional red brown earths because of the shallower topsoil.

The subsoils of transitional red brown earths may be of heavier texture than those of red brown earths and therefore may be more dense and impermeable, especially if sodic. Therefore, low permeability of the subsoil may reduce plant growth through waterlogging and poor aeration. These subsoils are also prone to compaction when wet.

When factors such as soil strength and poor aeration are taken into account the soil will have a very narrow range of water contents at which the roots can grow unimpeded by high soil strength or poor aeration.

The comparatively poor chemical and physical properties of the transitional red brown earths mean that farmers must improve the soils natural fertility if vegetables are to be produced economically.

Techniques that improve the structure of these soils improve production and the range of crops that can be grown on transitional red brown earths. For example, gypsum will temporarily improve structure and therefore improve the aeration, infiltration and permeability of transitional red brown earths, allowing increased plant production on these soils.

Chapter C4. Alluvial soils

PURPOSE OF THIS CHAPTER

To describe the characteristics of alluvial soils

CHAPTER CONTENTS

- appearance
- topography and vegetation
- land-use limitations and soil problems

ASSOCIATED CHAPTERS

- Part C

ALLUVIAL SOILS

Most of the fresh market and processing vegetables produced in the Macquarie and Lachlan Valleys are grown on the alluvial soils of the river flats and terraces.

Although there is some cropping on the clay black earths and alluvial sands, most vegetable production is on alluvial soil generally described as:

- prairie soils
- earthy loams
- layered alluvial loams (in the Lachlan Valley).

APPEARANCE

Alluvial soils have a range of features. The following descriptions are typical of the main soil profiles used for vegetable production.

Texture and colour: prairie soils

The topsoil is a black loam to clay loam with moderate crumb structure and pH 7.0 to 30 cm depth.

The subsoil in the Macquarie Valley is a blocky light clay, moderately structured with pH 7.5 overlying highly plastic brownish black clay.

In the Lachlan Valley the subsoil is a strongly structured reddish brown silty clay loam that can alter at 2 m to a dark yellowish brown silty clay loam with moderate structure.

Texture and colour: earthy loams

The earthy loams in the Macquarie Valley have a brownish black loam to clay loam with weak structure and pH 6.0 to 15 cm. The subsoil is a black clay loam with weak structure and pH increasing to 8.5 with depth.

In the Lachlan Valley the topsoil can be to 1 m depth of dark brown to brownish black silt loam, weak to moderately structured with a pH of 7.0.

The silt loam continues in the subsoil, with minor but distinct orange mottling at 1.2 m. The pH ranges down to 6.0 with depth. Note that these soils can extend to 3 m with little change in colour or texture.

Texture and colour: layered alluvial loams

The topsoil is dark brown to brown loamy sand to fine sand loam with weak structure, and is apedal massive or single grained. The pH is 6.0 to 8.0.

The subsoil is brown sandy clay loam with weak structure. The pH is 7.5 to 8.0.

TOPOGRAPHY AND ASSOCIATED VEGETATION

Macquarie Valley

In the Macquarie Valley there are alluvial plains and terraces with local relief (or local altitude variance) of often less than 10 m. Other elements, including backplains, swamps, channels, floodouts, ox-bows, levees and point bars, occur along the Macquarie River and on the Belubula River flood plain. The soil landscape varies from 100 to 1000 m wide, usually less than 300 m on the smaller alluvial plains along creeks. Slopes are level to 3% and are steeper on the slopes of terraces.
The alluvial channels tend to be slowly migrating, except on narrow alluvial plains.

An open savannah grassland with yellow box is the dominant native vegetation.

Lachlan Valley

The Lachlan Valley has alluvial plains and terraces with local relief less than 20 m. They vary in width from 50 to 300 m in areas bounded by steep slopes, to as wide as 3200 m on some flats along the Lachlan River. Slopes range from level to 3%. Terraces are often found beside deeply incised river channels with back plains.

White and grey box are the dominant native vegetation.

LAND USE LIMITATIONS/SOIL PROBLEMS

The alluvial river flats generally fit into the Class 1 land-use category, as they are most suitable for intensive cropping, with good natural physical and chemical soil properties.

The Macquarie River earthy loams can be hardsetting on the surface, with some patches of imperfect drainage, but generally the alluvial soils are loose at the surface, well drained and permeable, with good water-holding capacity. The watertable is generally deeper than 2 m, and salinity is not a major concern.

Flooding is the major concern in these districts; it causes crop losses and spreads soil-borne diseases. This is a particular problem in the Macquarie Valley with brassicae crops.

Seedling emergence on the earthy clay loams that hardset on the surface in the Macquarie Valley can be restricted. This problem can be managed correctly through practices like reducing cultivation and increasing organic matter.

Chapter C5. Self-mulching clays

PURPOSE OF THIS CHAPTER

To describe the characteristics of self-mulching clays

CHAPTER CONTENTS

- appearance
- topography and vegetation
- land-use limitations and soil problems

ASSOCIATED CHAPTERS

- Part C

SELF-MULCHING CLAYS

The self mulching clays have a uniform heavy clay texture from the surface to deep into the soil profile. The surface soil, when dry, is self mulching, being composed of easily disturbed small aggregates resulting from extensive swelling and shrinking from wetting and drying.

These soils are found in gilgai formations, usually in association with transitional red brown earths. The self-mulching clay soils occur as the mound or puff in gilgai formations, while in the lower areas between the mounds transitional red brown earths are usually found. The proportion of the mound compared with the shelf in gilgais varies. The proportion of the mound in a gilgai formation therefore influences the land-use options and management of a particular area. Areas with more than 50% mound as a proportion of the total area are usually considered to be self-mulching soils.

APPEARANCE

The colour of the self-mulching clay soils ranges from reddish brown to grey. This colour may tend to be more yellow with depth. Small white nodules of lime (calcium carbonate) may be seen on, or just under, the surface of these soils to depth.

When dry, the surface of these soils will have a soft feel when you walk over it, because the soil structure is excellent. This property makes these soils very easy to cultivate when dry. A shovel can be pushed into the surface of these soils with comparatively little effort.

CRACKING CLAYS

Many of the self-mulching soils in the vegetable-growing areas of the MIA are cracking clays. Cracking clays are dark (grey, reddish and black) soils, containing high amounts of clay (more than 50%), that crack on drying and swell on wetting throughout the profile and, most importantly, right to the surface. During summer, cracks of a few to tens of millimetres wide appear at the surface, but swell closed after the first winter rains. Many of these soils form a shallow (less than 100 mm thick) surface ‘mulch’ layer of small (1 to 2 mm diameter) aggregates during cycles of wetting and drying. After rain or irrigation, this ‘mulch’ may disappear as the aggregates swell into each other.

These soils are seldom used for the production of perennial crops, but are used for annual horticultural row crops such as tomatoes, cucurbits and sweet corn. They affect root growth in several ways. Young, perennial crops may be slow to establish, and high mortality may be observed in the first year after planting. Annual crops may perform well in the first year, but performance rapidly declines in subsequent years. The reasons for these responses are not well understood, and management systems that avoid rapid soil structure decline are not available. Some of the factors that are responsible for poor crop performance are:

- shallow root zones may be 'waterlogged' (roots suffer extreme lack of aeration) during winter and spring
- roots may be damaged by cracking of soil on drying in early summer
- young plant roots may have insufficient root–soil contact as a result of large cracks developing in the shallow root zone in summer, and water uptake may be sufficiently impaired to affect plant growth
- water availability may generally be limited because of the high clay content and the propensity of these soils to compact themselves (coalesce) even when not trafficked.

TOPOGRAPHY AND ASSOCIATED VEGETATION

Self-mulching clays occur as the mound or 'puff' in gilgai complexes. The vegetation most likely to be found on areas of self-mulching clay is:

- boree
- black box.

LAND USE LIMITATIONS AND SOIL PROBLEMS

The well structured self-mulching clays have a good mix of transmission pores (which allow water and air to move through the soil) and storage pores (which store water for use by plants); therefore, plant growth on these soils is usually very good compared with that on the other soil groups.

Self-mulching soils can withstand comparatively frequent cultivation without changes to structure. However, this may not be the case if they are cultivated while the soil is too wet. Tillage or traffic from machinery or animals in moist conditions is likely to cause compaction in these soils. Yield losses due to compaction may increase slowly over time. However, losses due to compaction will be large, and relatively sudden if the soil is cultivated when it is too moist. It is therefore important to make an assessment of soil moisture to the depth of cultivation before proceeding with the operation.

The effects of compaction from traffic can be largely eliminated if traffic is confined to furrows, as is the case in permanent raised bed systems of crop production. Permanent raised beds have other advantages.

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See Chapter D7 for more information on permanent raised beds.

OTHER SOILS

Vegetables are grown on many more soil types than those discussed in this Part of the manual. An example is the kraznozems, which are basalt-derived, well structured loamy soils high in organic matter used for potato production around Robertson in the Southern Highlands. However, the majority of vegetables are grown on the soil types discussed.

Chapter C6. Case study 2

PURPOSE OF THIS CHAPTER

To present a case study of good soil management

CHAPTER CONTENTS

- case study

ASSOCIATED CHAPTERS

- B11 Case study 1
- E3 Case study 3

CASE STUDY 2

Cedric Schofield of 'Glenelg', East Kangaloon, in the Southern Highlands of New South Wales, produces fresh potatoes for the Sydney market (Figure C6-1).

Figure C6-1.

Capitalising on his minimum-till operation, Cedric Schofield markets his potatoes as 'sustainably produced'. (Bernie McMullen)

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See Chapters C1 to C5 for more information on soil types.

The soil type is a well structured kraznozem with some heavier clay. The basalt-derived soils are high in organic matter, but traditional potato-growing practices of excessive cultivation can lead to structural decline. On this sloping land, erosion is a major concern.

Cedric does a three-block rotation with a north-east to south-east aspect.

To overcome the potential erosion problem a number of strategies are implemented. Contour banks are strategically placed to reduce slope length and act as silt traps; they can also be used as traffic ways. The banks and drains are sown with kikuyu.

A pasture/oats/potato rotation is practised, with minimum tillage. Traditional practice needs up to six cultivations to prepare a satisfactory seed bed.

The oaten cover crop is grazed (or sprayed with a knockdown such as glyphosate by some farmers), then tilled with a modified Agroplow® with a power harrow (Figure C6-2 and C6-3).

Figure C6-2.

Robertson potato grower Jack Hill inspecting an oaten cover crop sown immediately after the potato harvest. This crop is necessary to stabilise the soil and prevent erosion on the sloping soil. (Bernie McMullen)

The cultivator has tines fitted with a set of widesweeps designed to lift and fracture the subsoil. A gearbox driving two vertical rotor blades and powered by the tractor is bolted to the frame. These blades work up the ground behind the tines in a circular manner, cultivating the ground sufficiently in one pass without inverting or ‘turning over’ the soil. The speed of rotation of the tines can be altered according to the soil conditions prevailing at the time of ploughing.

Two passes using this minimum-till technique are the most needed to ensure a good crop (Figure C6-4).

Irrigation is done with overhead sprinklers, and the rate determined by tensiometer readings.

Figure C6-3.

The modified Agroplow® developed for the minimum-tillage trials run on a number of properties in the Robertson area from 1992 to 1996. (Guy Van Owen)

Figure C6-4.

One pass into a sprayed-off paddock is sufficient to prepare a seedbed for planting. Another advantage is that only rows into which potatoes are sown are disturbed by the rotary tines, thereby keeping the area and degree of ground disturbance to minimum. (Guy Van Owen)

A base N:P:K fertiliser regime based on soil tests is practised, and side-dressing with N and K occurs in wetter seasons when leaching may occur. To avoid erosion after harvest the cover crop is sown as soon as possible.

Integrated pest management strategies are used to reduce spraying, including irrigation to seal the ground and prevent potato moth infestation.

Yields average 40 t/ha; this compares most favourably with traditionally grown crops that have much higher cultivation costs as well as greater soil structural breakdown and erosion problems.

Full details of trials comparing growing systems are available in the Robertson District Potato Advancement and Landcare Association publication *Sustainable Potato Production in Highland Areas of Australia*, available from the Association—phone Sandra Lanz on (02) 4677 0198.