Vegetable R&D
Your national vegetable levy at work

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Healthy Soil Management

The management of soil is a key aspect to ensuring the economic and environmental sustainability of vegetable production. Good soil management practices have a direct impact both on- and off-farm.

Vegetable growers need to know:
- If the soil is suitable for the crop they want to grow
- If the soil can be improved or amended in some way
- What to look for in soil test reports
- What soil management actions are needed to produce better yields
- If appropriate inputs are being used

Improved soil health leads to better production performance, including reduced input costs for herbicides, pesticides and fuel, less wear on machinery and more efficient use of water and nutrients. It also directly leads to less erosion, water and nutrient loss and off-farm impact.

The bottom line

- Healthy soil is vital for the sustainability and profitability of vegetable farms.
- Soil can only be managed appropriately with understanding and measurement of key soil properties.
- Soil properties are inter-related. If one is suboptimal then it can have an affect on other soil properties.

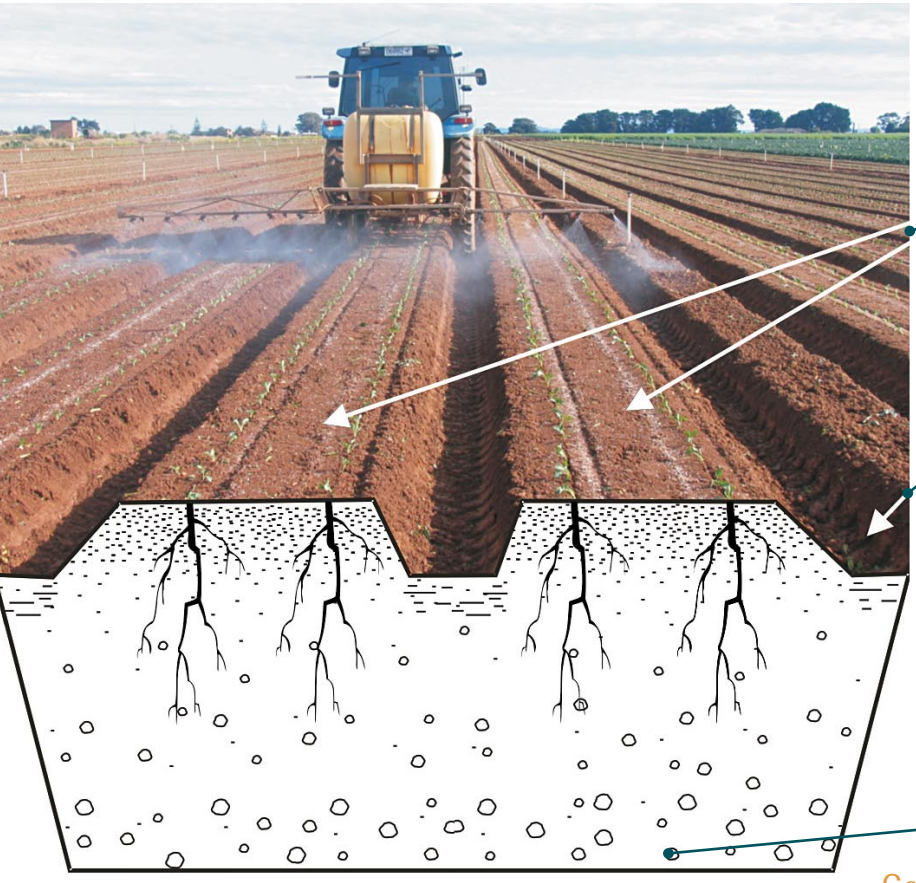


Figure 1. Features of an 'ideal' soil for vegetable production; Figure 2. Soil pit ready for inspection *(right)*

What is healthy soil?

For successful growth, soil needs to provide plants with water, nutrients, air and physical support.

Ideally, a healthy soil will have the features shown in Figure 1. However, it is rare to find a soil that is ideal in all soil properties. Vegetable growers often have to deal with several soil-related problems simultaneously. It should be the aim of vegetable growers to manage and improve their soil so that it can perform at its full potential. If any soil property is suboptimal, then other soil properties are also likely to be affected.

The shape and depth of roots are a good indication of soil condition. A healthy soil environment will allow roots to grow without limitation and extract nutrients and water from the soil. In compacted soil, root growth may be limited to the very top layer of soil. The presence of taproots growing at right angles is an indicator of a very compacted soil. In sandy soil, a thickened stubby appearance in impeded roots is associated with compaction.

Poor nutrition, waterlogging or toxic conditions such as strongly acidic, alkaline or saline layers, and high aluminium or boron conditions are some other reasons root growth may be restricted.

Getting to know your soil

In Australia, vegetables are grown on a wide range of different soil types. The only way that vegetable growers can know what limitations their soil might have, how much their soil varies across their property, how to calculate required quantities of soil amendments such as lime or fertiliser or the success of soil treatment is to examine the soil and to measure soil properties.

A backhoe, spade, coring tube or hand auger can be used to prepare, inspect and sample a soil profile. Using a backhoe to dig a soil pit (Figure 2) is particularly useful when developing a new paddock for vegetable production or to determine reasons for yield variation across a paddock or farm. Spades are useful for the rapid inspection of soil to a depth of about 30 cm. Corers and augers can be used at depths greater than that readily accessible using a spade but because of soil disturbance, soil analysis is limited to the assessment of chemical properties.

There are three main inspection zones in the root zone that need to be considered by vegetable growers:

1. Surface (0 – 10 cm): This is the soil zone that strongly influences seedling establishment and the infiltration of water.
2. Sub-surface (10 – 30 cm): This layer is usually the zone of maximum water uptake and nutrient extraction by plant roots.
3. Subsoil (30 – 120 cm): These deeper layers contain valuable reserves of water and nutrients, but can severely retard plant growth if problems such as waterlogging and salinity are present.

Key soil properties

For each soil layer there are a range of soil properties that can be examined to diagnose the condition of your soil.

→ Soil structural form *(compaction)*

Soil structural form is the arrangement of the solid components of soil and the spaces in between, which are called pores. It is important because it affects seedling establishment, root growth, and the flow of water and air into and through the soil. A soil with good structural form breaks up easily into small aggregates of soil.

→ Soil structural stability

When water is added to soil aggregates, the aggregates may collapse (slaking and dispersion). This can lead to the formation of hard layers which adversely affects air and water movement, root penetration and seedling establishment. Slaking is beneficial in cracking clays because it leads to the regeneration of good structural form (self-mulching).

→ Structural reslilience

Structural resilience is the ability of a soil to regain a desirable structural form after disruptive forces, such as the compactive pressures under the wheels of heavy machinery, have been removed. Regeneration usually occurs in clays that swell when wet and shrink when dry. Earthworms and plant roots also help with soil regeneration.

→ Soil texture

Soil texture is an estimate of the amount of sand, silt and clay in a soil. It strongly influences the structure of the surface layers of soil and therefore affects seedling emergence, water infiltration, trafficability and the ease of tillage. It also affects the water and nutrient holding capacity of the soil.

→ Soil colour

Soil varies considerably in colour. It is an indicator of whether the soil is well drained, such as red soil, or poorly drained, such as yellow or light grey soil. Mottling indicates that the soil is sometimes waterlogged.

→ Soil water holding capacity

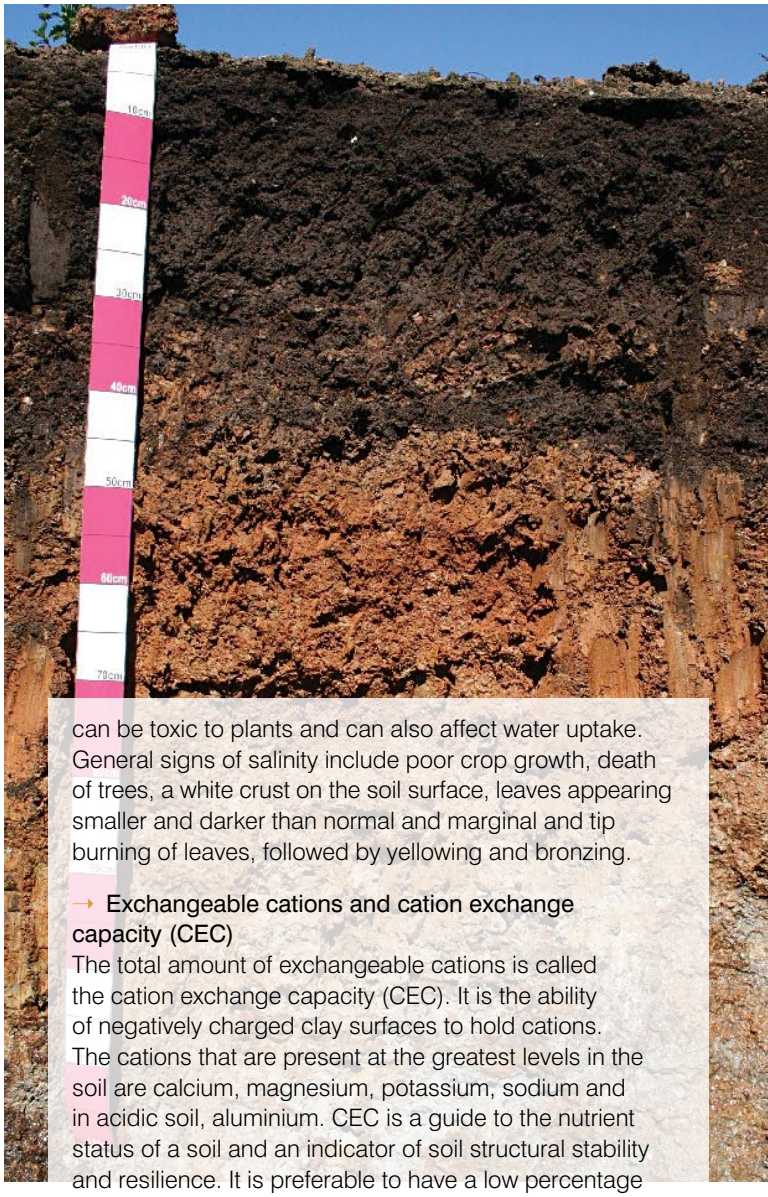
Plants need access to as much readily available water (RAW) as possible to prevent water stress. RAW is largely determined by the structural form and texture of a soil.

→ Soil pH

Soil pH is a measure of how acidic or alkaline a soil is. It has a scale from 1 (highly acidic) to 14 (highly alkaline). The pH is important because it affects the availability of nutrients that are essential for plant growth and the activity of microorganisms. Some nutrients may become unavailable as the soil becomes increasingly acidic or alkaline, while others may become available in toxic amounts.

→ Salinity/electrical conductivity (EC)

Salinity is the presence of soluble salts in the plant root zone or on the soil surface. The salinity of a soil is indicated by its electrical conductivity (EC). Plants have different susceptibilities to soil salinity. High salt levels



can be toxic to plants and can also affect water uptake. General signs of salinity include poor crop growth, death of trees, a white crust on the soil surface, leaves appearing smaller and darker than normal and marginal and tip burning of leaves, followed by yellowing and bronzing.

→ Exchangeable cations and cation exchange capacity (CEC)

The total amount of exchangeable cations is called the cation exchange capacity (CEC). It is the ability of negatively charged clay surfaces to hold cations. The cations that are present at the greatest levels in the soil are calcium, magnesium, potassium, sodium and in acidic soil, aluminium. CEC is a guide to the nutrient status of a soil and an indicator of soil structural stability and resilience. It is preferable to have a low percentage of sodium cations compared to calcium cations.

→ Nutrients

Vegetable crops will grow poorly if they are not provided with a balanced and adequate supply of nutrients. Macronutrients supplied by the soil are nitrogen, potassium, calcium, magnesium, phosphorus and sulphur. Micronutrients are chlorine, boron, iron, manganese, zinc, copper, nickel and molybdenum. Without soil nutrient data it is impossible to know the fertiliser requirements of a soil. Soil tests are useful to ensure that maintenance rates of fertiliser are not too high or too low and to highlight situations where higher fertiliser additions are required to overcome nutrient deficiencies.

→ Soil organic matter content

Soil organic matter is an essential feature of fertile and healthy soil. It consists of leaf litter, plant roots and organic materials associated with living soil microorganisms and soil animals, such as excreta. Soil organic matter has a strong influence on a soil's physical and chemical properties. It stabilises soil aggregates, provides energy and nutrients for microorganisms and adds to the CEC.

→ Soil fauna

Soil fauna includes earthworms, ants, nematodes, beetles, mites, termites, centipedes and millipedes. They play a key role in nutrient cycling, soil mixing and in creating biopores (improving soil structure). Some mesofauna, such as root feeding nematodes are harmful to crops.

→ Soil microorganisms

Soil microorganisms have a major role to play in organic matter decomposition and nutrient cycling. This group of organisms includes bacteria, fungi, algae and protozoa. Many beneficial organisms are present in most soil types but only proliferate when the soil and environmental conditions are suitable. Once problems with compaction, pH imbalance, nutrition and dispersion have been rectified, the biological health will also improve.

Improving soil and preventing future damage

No two vegetable farms, or even two paddocks, will have identical soil related problems. Therefore, most vegetable growers will need tailored soil management solutions, rather than a set and rigid approach.

Soil amendment strategies can only be decided upon if the condition of the soil is known. A combination of methods will usually be needed to optimise soil condition and to prevent problems occurring in the future.

Some of the methods available to vegetable growers include:

- Adding organic matter through green manure crops and animal manure
- Adding gypsum to improve structural form and stability
- Adding lime to improve structural form and stability and to increase pH
- Adding nutrients when sub-optimal levels are found in soil tests
- Deep tillage operations to loosen a compacted layer
- Encouraging earthworms to improve soil structural form
- Reducing the rate of soil acidification by applying nitrogen in small amounts more frequently to minimise leaching
- Using raised beds where there is a risk of waterlogging on flat land
- Implementing controlled-traffic farming to prevent compaction of plant beds
- Controlling soil erosion by avoiding excessive cultivation, establishing windbreaks and maintaining vegetation cover
- Avoiding waterlogging and deep losses of water and dissolved nutrients by having an irrigation and drainage management plan

Farm soil mapping

Information about soil properties gained from soil inspection can be used to generate soil maps and soil management maps. Soil management inputs should only be made where they are actually needed. Such decisions can only be made if there is a clear understanding of prevailing soil conditions, gained by regular soil inspection and monitoring.

Yield information, topography and remote sensing information (e.g. electromagnetic induction (EM) surveys and aerial photographs) can assist when making soil maps as they can be used to help fill in the gaps between where the soil was examined.

Soil information is an integral part of whole farm plans, which are required for growers wishing to implement an environmental assurance system such as EnviroVeg. They may also be required by Natural Resource Management bodies.

Soil consultants and laboratories can assist growers in examining and testing their soil and ensuring appropriate management decisions are made.

Further reading

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Australian Soil Science Society Incorporated <www.asssi.asn.au>

State Departments of Primary Industries

Cover image, Humus rich soil; p.4 Rip mulch

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