



## **SOILpak – cotton growers - Readers' Note**

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# Appendix 1. Sources of information





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Appendix 3. More case studies are  
needed



This *SOILpak for cotton growers* manual provides you with options for overcoming soil-related problems under irrigated and dryland cotton. It is your responsibility to select an option (or series of options) that is appropriate to your operation.

Fine-tuning of your soil management program to maximise profitability is likely to take several years. You will need to do strip trials of the various options at different rates and settings.

Often this fine-tuning process will be of great value to subsequent managers, and to other growers in the district. Therefore, it is important that you document these case studies.

District cotton grower associations have provided an excellent lead with the documentation of on-farm case studies. Cooperating growers and their consultants ensure that the various treatments under consideration are properly replicated. Otherwise, it is not possible to prove whether or not an improvement in performance was a real one.

Where soil management trials are established, aim to record more than just crop yield and quality.

Record:

- all costs and benefits associated with the various options
- the weather conditions under which the observations were made
- changes in soil condition, for example, the severity of soil compaction under the cotton plant lines.

Your information can then be incorporated into the next edition of *SOILpak for cotton growers*.

# Appendix 4. Unit conversion





**Table 1. Conversion factors that allow the electrical conductivity of saturated paste extracts ( $EC_e$ ) to be calculated from the electrical conductivity of 1:5 soil:water suspensions ( $EC_{1:5}$ ) and texture (source: Slavich & Petterson, 1993).**

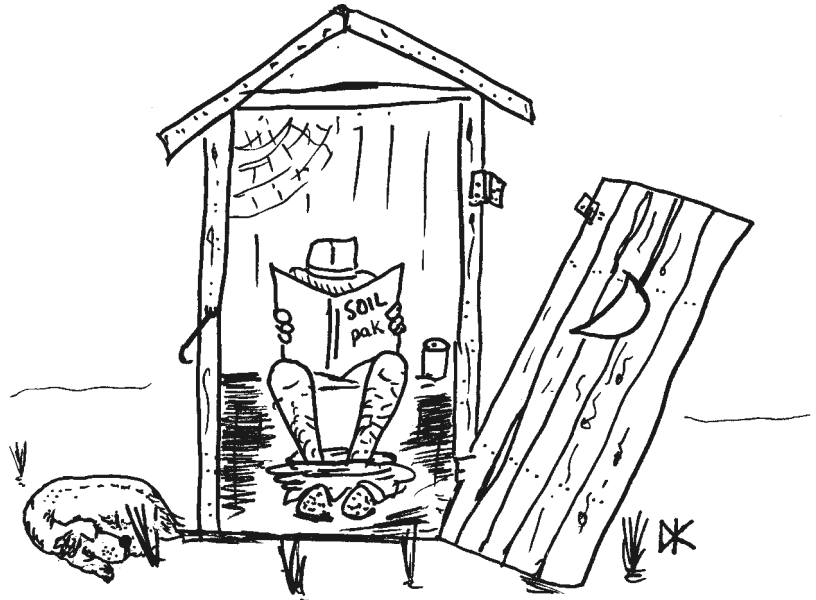
Texture grades (Northcote, 1979)	Conversion factor
Sand (S), loamy sand (LS), clayey sand (CLS)	22.7
Sandy loam (SL), fine sandy loam (FSL), light sandy clay loam (SCL)	13.8
Loam (L), loam fine sandy (Lfsy), silt loam (SiL), sandy clay loam (SCL)	9.5
Clay loam (CL), silty clay loam (SiCL), fine sandy clay loam (FSCL), sandy clay (SC), silty clay (SiC), light clay (LC), light medium clay (LMC)	8.6
Medium clay (MC)	7.5
Heavy clay (HC)	5.8

**Table 2. Conversions between electrical conductivity units and approximations to salt concentration (source: Shaw, 1985).**

To	S m <sup>-1</sup>	dS m <sup>-1</sup>	mS m <sup>-1</sup>	μS m <sup>-1</sup>	mS cm <sup>-1</sup>	μS cm <sup>-1</sup>	TDI mg L <sup>-1</sup>	m.equiv L <sup>-1</sup>	
From	multiply by								
S m <sup>-1</sup>	1	10	10 <sup>3</sup>	10 <sup>6</sup>	10	10 <sup>4</sup>	2/3x10 <sup>4</sup>	100	
dS m <sup>-1</sup>	0.1	1	100	10 <sup>5</sup>	1	10 <sup>3</sup>	2/3x10 <sup>3</sup>	10	
mS m <sup>-1</sup>	10 <sup>-3</sup>	0.01	1	10 <sup>3</sup>	0.01	10	20/3	0.1	
μS m <sup>-1</sup>	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-3</sup>	1	10 <sup>-5</sup>	0.01	2/3x10 <sup>-2</sup>	10 <sup>-4</sup>	
mS cm <sup>-1</sup>	0.1	1	100	10 <sup>5</sup>	1	10 <sup>3</sup>	2/3x10 <sup>3</sup>	10	
μS cm <sup>-1</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>	0.1	100	10 <sup>-3</sup>	1	2/3	0.01	
TDI, mg L <sup>-1</sup>	1.5x10 <sup>-4</sup>	1.5x10 <sup>-3</sup>	1.5x10 <sup>-1</sup>	1.5x10 <sup>2</sup>	1.5x10 <sup>-3</sup>	1.5	1	1.5x10 <sup>-2</sup>	
m.equiv, L <sup>-1</sup>	0.01	0.1	10	10 <sup>4</sup>	0.1	100	2/3x10 <sup>2</sup>	1	

**Example:** 1 μS m<sup>-1</sup> = 10<sup>-5</sup> dS m<sup>-1</sup>

## Appendix 5. Glossary – soil management terminology





<b>A, A1, A2 horizon:</b>	See: <i>soil profile</i> .
<b>access tube:</b>	Small diameter tube (typically 50 mm) inserted vertically through soil in the root zone to provide access for a neutron or capacitance probe. This allows estimation of the volumetric soil water content.
<b>acid soil:</b>	Soil with a pH value < (less than) 7.0.
<b>adsorbed:</b>	Held on a surface; in soil, <i>cations</i> are held on clay surfaces due to a difference in charge between the cations and the surfaces (similar to the attraction of oppositely charged ends of two magnets).
<b>aerobic:</b>	Soil conditions in which there is sufficient oxygen for plant roots and (generally) soil organisms that carry out processes beneficial to plant nutrition and soil structure.
<b>aggregate:</b>	A natural unit of soil that contains groups of peds; the peds within the aggregate are held together more firmly than the aggregate holds to other aggregates (therefore the aggregate is recognisable as a unit).
<b>aggrsize:</b>	Creation of 1–4 mm diameter clods in loam soil under moist conditions that, once dried, are stable on re-wetting.
<b>air-filled porosity:</b>	The fraction of the bulk volume of soil that is filled with air at the time of measurement.
<b>Alfisol:</b>	Loam soil with a clay-rich subsoil (U.S. terminology).
<b>alkaline soil:</b>	Soil with a pH value > (greater than) 7.0.
<b>allelopathy:</b>	Production of a substance by one organism that inhibits the growth of one or more other organisms.
<b>alley farming:</b>	Production of crops between regularly spaced, parallel strips where trees and/or perennial shrubs and grasses are grown.
<b>alluvial soil:</b>	A soil developed from recently deposited <i>alluvium</i> ; usually too young to show the effects of soil forming processes: any layers in the soil profile are successive deposits rather than soil horizons.
<b>alluvium:</b>	Unconsolidated gravel, sand, silt and clay deposited by water flow—typical of floodplains.
<b>ameliorate:</b>	To make or become better.
<b>anaerobic:</b>	Soil conditions in which there is a lack of oxygen, usually because water has replaced soil air (the soil is waterlogged); substances harmful to plants (such as hydrogen sulfide) may accumulate.
<b>anion:</b>	An <i>ion</i> with negative charge.
<b>apedal:</b>	Soil materials without peds, that is, structureless.
<b>aquifer:</b>	A water-bearing geologic unit of sediment or rock capable of yielding useful quantities of water to bores or springs.
<b>ASC:</b>	See: <i>Australian soil classification</i>
<b>ASWAT test:</b>	A measure of soil dispersion in water ( <b>A</b> ggregate <b>S</b> tability in <b>W</b> ATer) that takes between 2 and 4 hours to complete. The ASWAT test is a simplified version of the ‘Loveday and Pyle’ dispersion test.

<b>Australian soil classification (ASC):</b>	The system now used to classify soil in Australia; it replaces ‘Great Soil Groups’ and ‘The Factual Key’.
<b>available water capacity:</b>	See: <i>plant available water capacity</i> .
<b>B horizon:</b>	See: <i>soil profile</i> .
<b>back-to-back cotton:</b>	Planting of a cotton crop (around October) in a field where cotton was grown the previous season (usually harvested in April).
<b>bed:</b>	A raised pair of ridges of soil (usually 2 m wide, furrow to furrow, and sometimes flat on top) into which a row crop is planted; see: <i>hill</i>
<b>biological drilling:</b>	Using tap-rooted plants to penetrate through a hard layer of soil or into a hard subsoil; when the plants die, the root channels are available for use by subsequent crops.
<b>biological fertility:</b>	See: <i>fertility</i> .
<b>biological ripping:</b>	Using plants to dry and crack the soil; cycles of swelling and shrinking improve soil structure in cracking clays.
<b>biopore:</b>	A macropore created by biological activity in the soil, for example, old root channels, or chambers created by earthworms and ants.
<b>bleached:</b>	A pale colour (for example, of an A2 horizon); see: <i>Soil profile</i> .
<b>bolus:</b>	A ball of moist soil which is kneaded to determine soil texture.
<b>bulk density:</b>	A measure of compactness; the more compact a soil is, the more solids in a given volume. Bulk density is calculated as the weight of oven-dry soil divided by the field volume of the sample.
<b>Ca:Mg ratio:</b>	Ratio of exchangeable calcium to exchangeable magnesium.
<b>calcareous:</b>	A soil containing significant amounts of naturally occurring calcium carbonate (CaCO <sub>3</sub> )(lime), which fizzes when dilute acid is added.
<b>calcium:</b>	A <i>cation</i> that promotes <i>flocculation</i> ; an essential plant nutrient.
<b>capacitance probe:</b>	A sensor that estimates volumetric soil water content by measuring the dielectric properties of soil surrounding a PVC tube.
<b>cation exchange capacity (CEC):</b>	See: <i>exchange capacity</i> and <i>exchangeable cations</i> .
<b>capillary rise:</b>	The upward movement of water caused by the molecular attraction between soil particles and water; capillary rise causes the wetting of soil above a watertable.
<b>cation:</b>	An <i>ion</i> with a positive charge.
<b>CEC:</b>	See: <i>exchange capacity</i> and <i>exchangeable cations</i> .
<b>chemical fertility:</b>	See: <i>fertility</i> .
<b>chisel ploughing:</b>	Deep tillage at depths < 40 cm.
<b>Chromosol:</b>	A soil with a <i>duplex</i> texture profile and in which the major part of the upper 0.2 m of the B2 horizon is not <i>strongly acid</i> .

<b>clay:</b>	Soil particles with a diameter smaller than 0.002 millimetres that are involved in swelling and shrinking of soil, and hold water and exchangeable cations. The term ‘clay’ also refers to soil with sufficient clay (greater than 35%) to exhibit clay behaviour.
<b>clod:</b>	A human-modified unit of soil that often contains smaller component clods; see: <i>aggregate</i> and <i>ped</i> .
<b>coefficient of linear extensibility (COLE):</b>	The percentage shrinkage in one dimension of a moulded soil between two water contents.
<b>COLE:</b>	See: <i>coefficient of linear extensibility</i> .
<b>colloid:</b>	Material consisting of very finely divided particles. It has a large surface area per unit volume, so it is very reactive; <i>clay</i> and <i>humus</i> are colloids.
<b>compaction:</b>	Compression of soil into a smaller volume so that bulk density is increased and air-filled porosity is decreased; see: <i>smearing</i> , <i>remoulding</i> and <i>pulverisation</i> .
<b>conchoidal:</b>	‘Ball and socket’ morphology associated with severely compacted and remoulded soil.
<b>controlled traffic:</b>	The confinement of traffic over a field to the same wheel tracks, the position of which is fixed for several years.
<b>conventional tillage:</b>	Describes traditional systems where mechanical tillage is the main method used for seedbed preparation and weed control; normally involves 3 to 6 tillage operations.
<b>cracking clays:</b>	Black, grey or brown (occasionally, but rarely, red) clay soil that is distinguished by seasonal cracking and a lack of distinct horizons; see <i>Vertisol</i> .
<b>crop water use:</b>	The water used by a crop from planting to harvest. It includes transpiration (through the crop) and evaporation (directly from the soil), and is usually expressed in mm.
<b>crop water use efficiency (CWUE):</b>	See: <i>Water use efficiency</i> .
<b>crusting:</b>	Occurs when the soil surface ‘melts’ together when wet, and then sets hard and impermeable when dried. If a thin (up to 10 mm deep) surface layer is affected, and cannot be readily separated from and lifted off the underlying soil, the problem is called crusting; if thicker (particularly when the whole topsoil is affected) it is called hardsetting; see: <i>hardsetting</i> and <i>flaking</i> .
<b>deep percolation:</b>	Drainage of water below the root zone.
<b>deep ripping:</b>	Deep tillage at depths > 40 cm.
<b>deep tillage:</b>	Any tillage deeper than that needed to produce loose soil for a bed/hill or seedbed; its usual purpose is to loosen a compacted subsoil.
<b>denitrification:</b>	The processes by which soil microbes convert soil nitrate to nitrogen gas and nitrous oxide gas, which are unavailable to plants.
<b>discharge area:</b>	An area where underground water is discharged at the soil surface.
<b>dispersion:</b>	Disintegration of microaggregates into individual clay, silt and sand grains; it is the opposite of flocculation.
<b>dryland salinity:</b>	Symptoms of salinity associated with dryland agriculture.

<b>duplex soil:</b>	A soil that shows a sharp change in soil texture between the A and B horizons; for example, a loam topsoil overlying a clay subsoil; red-brown earths are duplex.
<b>EC<sub>1:5</sub>:</b>	The electrical conductivity of a 1:5 soil:water extract.
<b>EC<sub>e</sub>:</b>	The electrical conductivity of a saturated soil paste.
<b>electrical conductivity (EC):</b>	Conductivity of electricity through water or an extract of water, commonly used to establish the soluble salt content.
<b>electrochemical stability index (ESI):</b>	Soil electrical conductivity (dS/m) (1:5 soil:water extract) divided by exchangeable sodium percentage; it is a measure of soil stability in water.
<b>electrolyte:</b>	Salty solution.
<b>EM instruments:</b>	Electromagnetic induction devices that estimate soil salinity.
<b>Entisol:</b>	Loam without a clay-rich subsoil (U.S. terminology).
<b>erosion:</b>	The wearing away of the land surface by rain, irrigation water or wind, causing soil movement from one point to another.
<b>ESI:</b>	See: <i>electrochemical stability index</i> .
<b>ESP:</b>	See: <i>exchangeable sodium percentage</i> .
<b>evapotranspiration:</b>	The sum of direct evaporation from the soil surface and transpiration, by which process plants give off water vapour through their leaves.
<b>exchange capacity:</b>	Ability of the clay and humus in the soil to hold ions on charged surfaces. Negatively charged surfaces (cation exchange sites) hold cations; positively charged surfaces (anion exchange sites) hold anions. For cations, the capacity (cation exchange capacity; CEC) is expressed as centimoles of positive charge per kilogram of soil (cmol (+) kg <sup>-1</sup> ); for anions, the capacity is expressed as centimoles of negative charge per kilogram of soil (cmol (-) kg <sup>-1</sup> ); both are numerically equal to milliequivalents per 100 g of soil (meq/100g); see: <i>ion</i> .
<b>exchangeable cations:</b>	Positively charged <i>ions</i> held loosely on negatively charged soil particles, and readily exchanged with other ions in the soil solution. This mechanism reduces the leaching of some plant-available nutrients.
<b>exchangeable sodium percentage (ESP):</b>	The number of exchangeable sodium ions as a percentage of all exchangeable cations held by a soil. The critical ESP value above which dispersion occurs ranges from 2 to 15, depending on the amount of electrolyte in soil solution.
<b>fallow efficiency:</b>	The percentage of rainfall received during the fallow that is stored in the soil; soil management can alter fallow efficiency.
<b>fertility:</b>	The capacity of a soil to support plant growth. It has three components—chemical, biological and physical fertility.  <i>Chemical fertility</i> is the ability of a soil to supply plants with an adequate and balanced supply of nutrients.  <i>Biological fertility</i> refers to the nature and diversity of soil organisms, and their activity in the soil.  <i>Physical fertility</i> is the ability of a soil to supply plants with enough water and oxygen, to protect their roots from temperature stress, and to allow unrestricted root penetration and shoot emergence; it depends largely upon soil texture and structure.

<b>field capacity:</b>	The content of water, on a mass or volume basis, remaining in a soil after free drainage has become negligible (corresponds to a soil water potential of $-10$ kPa).
<b>flaking:</b>	Structural condition of topsoil in which the surface layer, usually less than 10 mm thick, is hard and brittle when dry and can be readily separated from and lifted off the underlying soil; see: <i>crusting</i> .
<b>flocculation:</b>	Clustering of clay particles into microaggregates; the opposite of dispersion.
<b>friability:</b>	The ease with which a soil sample can be crumbled.
<b>geographic information system (GIS):</b>	A method (usually computer based) of overlaying and comparing large volumes of geographic data of different kinds.
<b>gilgai:</b>	A natural surface feature of humps and depressions found in some types of cracking clay.
<b>GIS:</b>	See: <i>geographic information system</i> .
<b>global positioning system (GPS):</b>	A network of satellites controlled by the US Department of Defence that is designed to determine a radio receivers position in latitude, longitude and altitude. Differential GPS (DGPS) improves accuracy of the information via the use of a local base station.
<b>‘go-devil’:</b>	Triple-disc ridge cultivator.
<b>GPS:</b>	See: <i>global positioning system</i> .
<b>gravimetric water content:</b>	The water content of the soil on a per weight basis; grams of water per gram of soil (also referred to as wetness).
<b>ground truthing:</b>	Verification of the accuracy of data by actual field investigation of areas that have been remotely sensed.
<b>‘guess row’:</b>	A row at the outside edge of the cultivation implement; the distance between successive runs of the bed-forming implement has to be ‘guessed’ to some extent by the tractor driver—hence the name.
<b>gypsum:</b>	Calcium sulfate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), used to reduce swelling and dispersion in sodic soil; it is either a naturally mined substance or a by-product of fertiliser manufacture.
<b>hardsetting:</b>	Occurs when a layer of soil, not necessarily at the surface, ‘melts’ together when wet, and then sets to be hard and impermeable when dried. Hardset layers generally are thicker than a crust, and often contain a disconnected series of small air-filled pores that resemble honeycomb. Hardsetting often occurs in soil with insufficient swelling clay and organic matter; see: <i>crusting</i> .
<b>‘head ditch’:</b>	Channel, carrying water to the high end of a field, from which water flows into furrows via siphons.
<b><i>Heliothis armigera</i>:</b>	A species of moth (also referred to as <i>Helicoverpa armigera</i> )— its larvae damage cotton and many other crops. Some individuals are resistant to the pesticides endosulfan and pyrethroids.
<b>hill:</b>	A ridge of soil (usually 1 m wide, furrow to furrow) into which a row crop is planted; see: <i>bed</i> .
<b>horizon:</b>	A layer of soil in the soil profile, different from layers above or below due to differences in colour, texture and/or structure. Horizons are formed by soil-forming

	processes, as distinct from strata due to successive deposition, or modification caused by the passage of farming machinery; see: <i>alluvium</i> , <i>soil profile</i> .
<b>humus:</b>	Stable, large organic molecules produced by the decomposition of once-living organisms.
<b>hydraulic conductivity:</b>	The rate of flow of water per unit gradient of hydraulic potential.
<b>illite:</b>	A type of clay mineral.
<b>impermeable:</b>	Transmits no water or air.
<b>infiltration:</b>	Movement of water into a soil.
<b>infrared:</b>	Referring to the portion of the electromagnetic spectrum with wavelengths just beyond the red end of the visible spectrum.
<b>ion:</b>	Atomic or molecular particle carrying an electrical charge.
<b>irrigation efficiency (IE):</b>	See: <i>water use efficiency</i>
<b>Kandosol:</b>	A soil that has a well-developed B2 horizon in which the major part is <i>massive</i> or has only a weak grade of structure, and has a maximum clay content in some part of the B2 horizon that exceeds 15%.
<b>kaolinite:</b>	Variable-charged clay mineral with a 1:1 layer structure.
<b>Kurosol:</b>	A soil with a <i>duplex</i> texture profile and in which the major part of the upper 0.2 m of the B2 horizon is <i>strongly acid</i> .
<b>landforming:</b>	An earthmoving operation that creates a desirable field slope.
<b>leaching:</b>	Downward movement of dissolved materials.
<b>levee:</b>	Recently deposited alluvium beside a river; a levee is higher than the surrounding plains.
<b>‘lilleston’:</b>	Rolling cultivator for shallow tillage of soil surface. It is used for inter-row cultivation after cotton has been planted
<b>lime:</b>	Calcium carbonate ( $\text{CaCO}_3$ ), occurring in rocks as limestone or chalk, and in some soil as fine particles or small nodules; finely-ground limestone (‘aglime’) is used to raise soil pH and/or overcome sodicity; other forms of lime are hydrated lime (calcium hydroxide) and burnt lime (quicklime, calcium oxide).
<b>listing:</b>	A tillage and landforming operation using a tool that splits the soil and turns two furrows laterally in opposite directions, leading to a ridge and furrow soil configuration.
<b>lower plastic limit (LPL):</b>	Old name for the <i>plastic limit</i> .
<b>macropore:</b>	Large (>0.03 mm diameter) soil pore that is drained and aerated at <i>field capacity</i> . It may be a biopore or an old crack line; see: <i>mesopore</i> , <i>minipore</i> .
<b>magnesium:</b>	A cation that promotes dispersion, but less so than sodium; an essential plant nutrient.
<b>massive:</b>	A coherent or solid mass of soil, largely devoid of natural lines of weakness.

<b>meander plain:</b>	An alluvial area built up by sediment from a slow moving and winding river.
<b>mesopore:</b>	Soil pore with a diameter 0.2 µm to 0.03 mm; able to store plant available water (1000 µm = 1 mm).
<b>microaggregates:</b>	Units of soil (smaller than 0.25 mm) that contain particles ranging in size from clay (smallest) through silt to fine sand.
<b>micropore:</b>	Soil pore with a diameter less than 0.2 µm; responsible for the storage of unavailable water in a soil.
<b>‘middle busting’:</b>	Deep tillage of soil, confined to areas under the plant lines so that wheel tracks remain intact.
<b>mineralisation:</b>	The processes by which soil microbes convert organic nitrogen to ammonium; see <i>nitrification</i> .
<b>minimum tillage:</b>	Also referred to as ‘reduced tillage’; describes farming practices that reduce the number of tillage operations compared with conventional tillage; weeds in the fallow are controlled by herbicides, and some tillage.
<b>moisture potential:</b>	See: <i>soil water potential</i>
<b>moisture seeking:</b>	Refers to planting implements that penetrate dry soil and place seed where there is sufficient moisture for germination.
<b>mole drain:</b>	A tubular drain formed beneath the soil surface by pulling an expanding plug through wet soil.
<b>montmorillonite:</b>	See: <i>smectite</i>
<b>mottled:</b>	Having blotches of soil with a different colour; indicative of past periods of intermittent waterlogging.
<b>Munsell colour system:</b>	A colour designation system that specifies the relative degrees of the variables of colour: hue, value and chroma.
<b>mycorrhiza:</b>	A fungus that attaches itself to plant roots, giving mutual benefits; also referred to as ‘vesicular-arbuscular mycorrhizae’ (VAM).
<b>neutron probe:</b>	A radioactive moisture sensor that is lowered down an aluminium access tube. It estimates volumetric soil water content through measurement of neutrons that are scattered by hydrogen atoms in soil water.
<b>NFR:</b>	See: <i>nitrogen fertiliser recovery</i> .
<b>nitrification:</b>	The processes by which soil microbes convert ammonium to plant-available nitrate.
<b>nitrogen fertiliser recovery:</b>	The proportion of applied fertiliser nitrogen that is taken up by the cotton plant.
<b>nitrogen fixation:</b>	The process of converting atmospheric nitrogen into compounds that eventually become available to plants. One such process is the fixation of nitrogen by Rhizobium bacteria associated with the roots of legumes; free-living soil organisms also fix nitrogen.
<b>nodule:</b>	An accumulation of a soil material as a discreet, small lump; may be composed of iron or manganese compounds, or calcium carbonate (lime); a swelling on the roots of legumes, containing symbiotic Rhizobium bacteria.

<b>non-limiting water range (NLWR):</b>	The region bounded by the upper and lower soil water contents over which water availability, oxygen and mechanical resistance to root growth is not limiting to plant growth.
<b>organic carbon:</b>	One of the chemical elements making up organic matter. Organic matter is often expressed as organic carbon because it is carbon that is measured in the laboratory; organic carbon multiplied by 1.75 gives an estimate of organic matter (soil organic matter is approximately 57% carbon).
<b>organic matter:</b>	Plant and animal material, living and dead.
<b>pan:</b>	A hard soil layer, which may restrict the entry of water, air and roots; if caused by repeated tillage at the same depth it is referred to as a plough pan.
<b>PAWC:</b>	See: <i>plant available water capacity</i> .
<b>ped:</b>	An individual natural soil aggregate consisting of a cluster of primary particles and separated from adjoining clusters by surfaces of weakness that are recognisable as being natural.
<b>pedal:</b>	Applied to soil materials consisting mostly of peds.
<b>percolation:</b>	Movement of water through the soil.
<b>permanent beds:</b>	A tillage system where the beds and furrows (wheel tracks) are left in the same place for a number of crops; see: <i>controlled traffic</i> .
<b>permanent wilting point:</b>	The largest water content of a soil at which indicator plants, growing in that soil, wilt and fail to recover when placed in a humid environment (corresponds to a soil water potential of $-1500$ kPa).
<b>permeability:</b>	Ability of a soil to transmit water and gases.
<b>pH:</b>	The acidity or alkalinity of a soil is measured as pH, which is an indication of the concentration of hydrogen ions in soil solution. The pH values increase as the concentration of hydrogen ions decreases.
<b>pH buffering capacity:</b>	The ability of a soil to resist changes in pH. It increases as the clay and organic matter content become greater.
<b>physical fertility:</b>	see: <i>fertility</i> .
<b>picker row (PR):</b>	Plant row adjacent to a furrow wheeled only by cotton pickers; see: <i>tractor row</i> .
<b>PR:</b>	See: <i>picker row</i> .
<b>piezometer:</b>	A non-pumping shallow bore, of small diameter, to measure the pressure level of groundwater.
<b>PL:</b>	See: <i>plastic limit</i>
<b>plant available water capacity (PAWC):</b>	The maximum amount of water that a soil can hold in the root zone and later release to plant roots. Water held between ‘field capacity’ and ‘refill point’ is referred to as being readily available.
<b>plastic limit (PL):</b>	The water content of a soil above which it can be remoulded (is plastic) and below which it cannot be remoulded (is brittle).
<b>plastic:</b>	Capable of being moulded.
<b>platy clods:</b>	Soil aggregates with horizontal dimensions greater than vertical dimensions.
<b>pore:</b>	Channel or cavity in a soil.

<b>porosity:</b>	The degree to which a soil is permeated with pores; the term refers not only to the fraction of the soil volume made up of pores, but also to the size and shape of the pores and the degree of connection between them.
<b>profile:</b>	See: <i>soil profile</i> .
<b>pulverisation:</b>	Mechanical destruction of soil aggregates, usually when in a dry condition; see: <i>compaction, smearing, remoulding</i> .
<b>recharge area:</b>	A zone where surface water from rain, irrigation or streams infiltrates the soil and adds water to the groundwater system.
<b>red-brown earth:</b>	A soil with a loamy topsoil (sometimes hardsetting) overlying a red clay-rich subsoil.
<b>refill point:</b>	The soil water content at which the rate of extraction of soil water by a crop declines due to a lack of soil water.
<b>remote sensing:</b>	Detection and/or identification of landscape features without having the sensor in direct contact with the object.
<b>remoulding:</b>	Reorganising pore space and natural clay orientation (without an increase in bulk density) by disturbing a soil when it is wet; see: <i>compaction, smearing, pulverisation</i> .
<b>rill erosion:</b>	An erosion process on sloping land in which numerous and randomly occurring small channels only several centimetres deep are formed.
<b>root zone:</b>	That part of a soil where the majority of live plant roots are located.
<b>saline seep:</b>	Bare, damp, salt affected area resulting from the seepage of saline groundwater.
<b>salinity:</b>	An excess of water-soluble salts (dominantly sodium chloride in Australia) that restricts plant growth.
<b>sand:</b>	Soil particles with a diameter between 0.02 mm and 2 mm; fine sand is 0.02–0.2 mm, coarse sand is 0.2–2 mm.
<b>SAR:</b>	See: <i>sodium adsorption ratio</i> .
<b>sediments:</b>	Particles of clay, silt and sand carried by water or wind before deposition.
<b>self-mulching:</b>	Refers to the topsoil of cracking clay that develops a crumbly layer of loose, small aggregates after a series of wetting and drying cycles.
<b>shrink-swell behaviour:</b>	Ability of a soil to shrink when dried and swell when rewetted.
<b>silt:</b>	Soil particles with a diameter between 0.002 mm and 0.02 mm; intermediate between clay and sand.
<b>slaking:</b>	Collapse of aggregates in water to form microaggregates, due to the breakage of bonds formed, for example, by organic matter.
<b>slickenside:</b>	Shiny, striated stress surface found on clay-rich aggregates, formed by one mass of soil sliding past another during swelling and shrinking cycles.
<b>smearing:</b>	Aligning of clay particles when mechanically disturbed under moist conditions, producing a shiny, impenetrable surface overlying a thin layer with high bulk density; see: <i>compaction, remoulding, pulverisation</i> .
<b>smectite:</b>	Negatively charged clay mineral with a 2:1 layer structure.

<b>sodicity:</b>	An excess of exchangeable sodium, causing dispersion to occur.
<b>sodium adsorption ratio:</b>	The concentration of sodium ions in water (meq/L), divided by the square root of [(concentration of calcium + concentration of magnesium) ÷ 2].
<b>Sodosol:</b>	A soil with a <i>duplex</i> texture profile and in which the major part of the upper 0.2 m of the B2 horizon is <i>sodic</i> and is not strongly <i>subplastic</i> .
<b>soil profile:</b>	The vertical sequence of layers (horizons) in the soil.  The <i>A horizon</i> is the zone with greatest amount of leaching; it may consist of an A1 horizon ('true topsoil'—higher in organic matter, darker and richer in biological activity than other horizons) and an A2 horizon (similar to A1 but paler, poorer in structure, lower in clay content and less fertile); the A2 horizon does not always occur;  The <i>B horizon</i> is the zone of accumulation of materials from above—clay, iron, aluminium and organic matter (although the organic matter content is never as high as in the A horizon); structure is different from that of A or C horizons and colour is typically stronger;  The <i>C horizon</i> consists of weathered rock, little affected by soil forming processes; soil that has developed on alluvium does not have a C horizon—the rock below is not related to the soil and would be termed the D horizon.
<b>soil structure:</b>	The combination or arrangement of primary soil particles into secondary units or peds. Naturally-formed peds (aggregates) are referred to as clods when the soil has been disturbed by the activities of humans; see: <i>structural form</i> , <i>structural resilience</i> , <i>structural stability</i> .
<b>soil water:</b>	Water stored in the soil, or moving through it via drainage.
<b>soil water potential:</b>	The amount of 'suction' that must be applied by plant roots at a particular soil water content for water uptake to commence.
<b>SOILpak score:</b>	A semi-objective rating (on a scale of 0.0 to 2.0) of soil structural form.
<b>SOLICON:</b>	A computer-based image analysis system for the assessment of soil structural form.
<b>solonetz:</b>	An old term describing a soil with a thin, friable surface soil overlying a hard, columnar subsoil that may be very alkaline.
<b>stubble retention:</b>	Soil preparation procedures that maximise the amount of stubble retained on the soil surface for soil and water conservation.
<b>structural form:</b>	A description of soil structural units (peds or aggregates) and the pore spaces between; it includes the shape and size of peds, the nature of their faces and their porosity (also referred to as 'soil architecture' and 'compaction severity').
<b>structural resiliency:</b>	Ability of a soil to regain structural form by natural processes, for example, swelling and shrinking, after the removal of disruptive stresses such as compaction by farm machinery.
<b>structural stability:</b>	The ability of a soil to retain its structural form under the influence of disruption caused by: a. immersion in water; b. compaction, remoulding and smearing.
<b>subbing:</b>	The rate of lateral flow of water from furrows into raised beds or hills.
<b>subplastic:</b>	Soil material that has an apparent increase in clay content as a bolus continues to be manipulated.

<b>sub-surface soil:</b>	Soil between the depths 10–30 cm.
<b>subsoil:</b>	Soil between the depths 30–120 cm. It is subdivided into Upper subsoil (30–60 cm), Mid subsoil (60–90 cm) and Lower subsoil (90–120 cm).
<b>surface sealing:</b>	The deposition by water, and/or packing, of a thin layer of fine soil particles on the immediate surface of a soil, greatly reducing its permeability.
<b>tensiometer:</b>	A device for measuring soil water potential, via a permeable ceramic cup inserted into the soil.
<b>texture:</b>	The relative proportions of sand, silt and clay in a soil sample. It can either be estimated by hand, or measured in the laboratory using particle size analysis (PSA).
<b>TDR:</b>	See: <i>time domain reflectometer</i> .
<b>texture contrast:</b>	See: <i>duplex soil</i> .
<b>time domain reflectometer (TDR):</b>	A device that uses the timing of wave reflections along steel rods to determine the properties of various materials, for example the dielectric constant of soil as an indication of soil water content.
<b>topsoil:</b>	Soil between the depths 0–10 cm.
<b>TR:</b>	See: <i>tractor row</i> .
<b>tractor row (TR):</b>	Plant row next to furrow driven along by tractors pulling planting and cultivation equipment ('main' wheel track); see: <i>picker row</i> .
<b>transpiration:</b>	See: <i>evapotranspiration</i> .
<b>VAM:</b>	See: <i>mycorrhiza</i>
<b>Vertisol:</b>	Cracking clay (U.S. terminology); see: <i>Vertosol</i>
<b>Vertosol:</b>	Australian term used to describe a soil which 'turns' (tills) itself (Latin <i>verto</i> —to turn). Vertosols have more than 35% clay throughout the profile, cracks greater than 5 mm at some time of the year, and the presence of slickensides. Vertosols lack distinct horizons.
<b>volumetric water content:</b>	The water content of the soil on a per volume basis (cm <sup>3</sup> of water per cm <sup>3</sup> of soil); it is equal to the gravimetric water content multiplied by the soil bulk density.
<b>water potential:</b>	See: <i>soil water potential</i> .
<b>watertable:</b>	Upper surface of groundwater, below which the layers of soil, rock, sand or gravel are saturated with water.
<b>waterlogging:</b>	Saturation of a soil with water, causing air to be displaced to the point where there is insufficient oxygen for unrestricted root activity; see: <i>anaerobic</i> .
<b>water use efficiency:</b>	A measure of the efficiency of conversion of water into plant products. For cotton, <i>crop water use efficiency</i> (CWUE) is a measure of lint yield per millimetre of water obtained from stored reserves in the soil, irrigation and rain. Calculation of <i>irrigation efficiency</i> (IE) is similar, but it takes into account water losses in the storage and distribution system.
<b>wilting point:</b>	See: <i>permanent wilting point</i>