Barossa Bushgardens

Place Plants People

SOIL HEALTH

Healthy soil means healthy people. Together with sunlight and water, it provides the basis for all terrestrial life. That includes the biodiversity around us, field crops that we harvest for food and fiber, but also pastures that feed our animals, gives meat, milk, eggs and wool.

It supplies nutrients, water and oxygen to plants. Soil is populated by microorganisms, essential for decomposing and recycling of leaf litter. It also resists erosion and stores water.

Healthy soil is productive, sustainable and profitable in an agricultural setting, but also provides for native vegetation, which in turn produces oxygen and absorbs carbon dioxide.

Soil also stores carbon from decomposing materials rather than releasing it into the atmosphere.

In this edition you will learn about the functions of plants, soil texture and structure, pH, salinity and sodicity, watering and you are welcome to do some simple soil tests to determine what soil you have and how you can improve it.

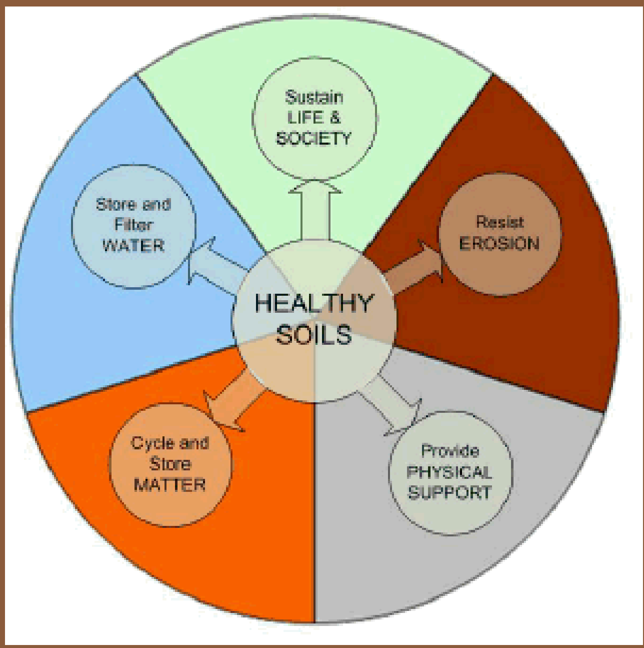


Image: Healthy soils, Source: agriculture.gov.au

HOW PLANTS WORK

The roots of a plant take up water and nutrients from the soil and transport it through the stems to the leaves. The leaves in turn are like food producing and processing factories.

Carbon dioxide enters them through the stomata - tiny openings on the leaf's surface. Eventually it gets to the chloroplasts - the small bodies inside leaf cells that give them their green colour. There, together with water, various chemicals and the energy of sunlight, the carbon of the carbon dioxide is used to make sugars and releases oxygen at the same time.

This process is called photosynthesis.

Sugars are the basic building blocks for all the other compounds of which plants are made:

- carbohydrates such as cellulose for cell walls and starches for energy reserves
- lignin for cell walls
- proteins and vitamins for cell contents and seeds
- flavours for fruit
- enzymes and hormones to make it all happen.

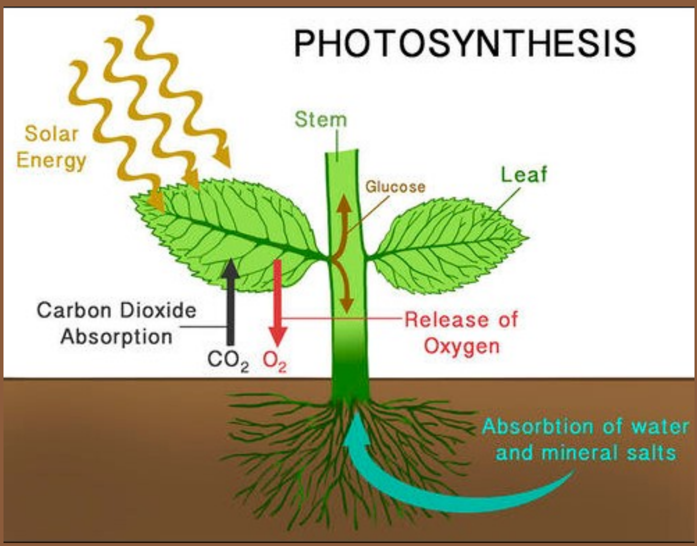


Image: Photosynthesis, Source: grotek.net

The sugars and other compounds are moved to wherever in the plant they are needed. Energy reserves are converted back into sugars when these are needed for rapid growth.

The stomata must be open to absorb carbon dioxide and release oxygen, meaning that water vapour is lost through them as well. This loss is called transpiration.

When water is transpired from leaf surfaces, a deficiency of water is created inside them, which gives the necessary 'pull[to raise water up through the plant.

So what does that have to do with the soil?

The roots of plants need both, water and oxygen, but if there is too much water and no oxygen, the roots will wilt.

Temperature is also a factor worth looking at, as most plant roots will die if the temperature of the soil is above 35°C for a prolonged time. Twenty minutes at 45°C is enough to kill most young roots.

In summary, soil must provide plants with nutrients, water, oxygen, room to develop and minimal risk of disease.

Soil Basics

Soil has usually five main components:

- mineral particles - the inorganic fraction
- organic matter - the remains of living organisms
- water - the 'soil solution' in which nutrients for plants are dissolved
- air - which fills the space between solid particles not filled with water
- living organisms - small animals and microbes

The proportions between each of the components varies with each soil type and the properties can be put into one or other of three groups:

- Physical properties are those properties we can see and feel. Included are colour, structure, texture and behavior towards air and water.
- Chemical properties involve chemical reactions and the supply of plant nutrients.
- Biological properties have to do with living organisms, both visible and invisible to the unaided eye.

These properties interfere with and change each other.

DETERMINING SOIL TEXTURE

There is a simple test to determine the texture of soil, which can tell us a lot about the interaction of water with the soil and how it will behave during cultivation.

1. Take a small sample of soil, sufficient to fit comfortably in the palm of one hand and discard obvious pieces of gravel.
2. Moisten the soil with water, a little at a time, and knead until there is no apparent change in the way it feels. Kneading will break aggregates so that they are no longer felt. This may take several minutes. The moisture content should be such that the soil just fails to stick to the fingers.
3. Inspect the sample to see if sand is visible; if not, it may still be felt and heard as the sample is worked.
4. Squeeze the sample hard to see whether it will form a ball or cast, and if so, whether the cast is durable or falls apart readily.
5. Squeeze it out between the thumb and forefinger with a sliding motion and note the length of self-supporting ribbon that can be formed.

Photo: Determining soil texture, Source: Colwynn Garden Design

Knowing the texture of your soil will help you with your plant selection. Most nurseries offer information about which plants likes which type of soil.

Soil Texture	**Description**	**Length of Ribbon**
Sand	No coherence; cannot be moulded; single grains stick to fingers.	
Loamy sand	Forms a fragile cast that just bears handling; gives a short ribbon that breaks easily; discolours fingers.	6mm
Sandy loam	Forms a cast that will just bear handling; individual sand grains can be seen and felt	15-25mm
Fine sandy loam	As for sandy loams, except that individual sand grains are not visible, although they can be heard and felt	15-25mm
Loam	Forms a coherent cast that feels spongy but with no obvious sandiness or 'silkiness'; may feel greasy if much organic matter is present	25mm
Silty loam	Coherent but will crumble; very smooth and silky	25mm
Sandy clay loam	Forms a strongly coherent cast in which sand grains can be felt	25-28mm
Clay loam	Forms a coherent cast with a rather spongy feel; plastic when squeezed between thumb and forefinger; smooth to manipulate	40-80mm
Sandy clay	Forms a plastic cast, except that sand grains can be seen, felt or heard	50-75mm
Light clay	Smooth plastic cast; slight resistance to shearing between thumb and forefinger	50-75mm
Medium clay	Smooth plastic cast, handles like plasticine and can be moulded into rods without fracture; some resistance to ribboning	> 75mm
Heavy clay	Smooth plastic cast that handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to ribboning	> 75mm

USING INFORMATION ABOUT SOIL TEXTURE

If the soil texture is known, some guesses can be made about some of its properties.

Clay will probably be difficult to cultivate, It will be sticky when wet and tough and cloddy when dry. Water will infiltrate (move into) it and percolate through it slowly. It may easily become waterlogged . It will probably have a moderate organic matter content and a good supply of most nutrients, but here are exceptions. Some clays crack deeply and so allow rapid and deep water penetration until the cracks close.

Sandy soils will probably have little organic matter, allow rapid infiltration and drainage of water, hold little water for plants and are easy to cultivate. They will usually be poor suppliers of plant nutrients. However, some sandy soils are water repellent.

Loams are supposed to be ideal for growing plants. They are easy to dig, give a fine seed bed and good conditions for root growth. They drain freely, yet hold moderate amounts of water and nutrients for plants. Loams have a wide range of compositions and an even wider range of properties. Some set like concrete; some are like fine powder. Crusts that form on some reduce water entry to near zero and some are very poorly endowed with nutrients.

Soil texture gives information only about the size of the particles in the soil. Usually these particles are grouped together into aggregates or crumbs. The arrangement of these crumbs gives a soil its characteristic structure. Structure is often more important than texture in determining how a soil behaves towards water and plant roots.

IMPROVING SOIL STRUCTURE

Crumbs come in all sizes, from small clay mineral particles (0.2mm) to clods (anything more than 5mm). A good structured soil will have anything from 0.2mm to about 3mm across. They come in all shapes and in undisturbed soil many crumbs fit loosely together into larger units that can easily be broken apart between finders or during cultivation.

Organic Matter

Organic matter is essential to the formation of soil crumbs, and so are soil microbes. Soil microbes feed on organic matter and produce crumbs by secreting slimes and binding soil particles together.

This does not happen overnight. To improve the building of crumbs and therefore the soil structure, we need microbes, food for them (organic matter), plant roots (to stabilize the soil), and time to allow the other three to interact undisturbed, meaning - no cultivation.

Infiltration

Water arriving on the soil, either through rain or irrigation, will either soak in, remain on the surface or run off. Only the water that actually soaks in is going to be of much benefit to plants.

Generally, sandy soils equal coarse particles and therefore water will infiltrate quickly, but also drain fast. On the other end of the spectrum is clay, which is comprised of very small particles and the rate of infiltration is significantly reduced.

Some soils build crusts and will not let any water penetrate, unless the surface is broken. The same can be said for soils that are soft, but water repelling.

Water Repellence

The grains in some very sandy soils are sometimes coated with organic materials and can in severe cases cause water droplets to sit on top of the dry soil.

Where possible, the best long-term cure would be to increase the clay content of the soil to above 8-10%, but agitating the soil while wetting it, and preventing it from drying out with organic mulch, will also help overcome the problem.

Image: Droplet on water-repellent soil, Source: soilquality.org.au

PH

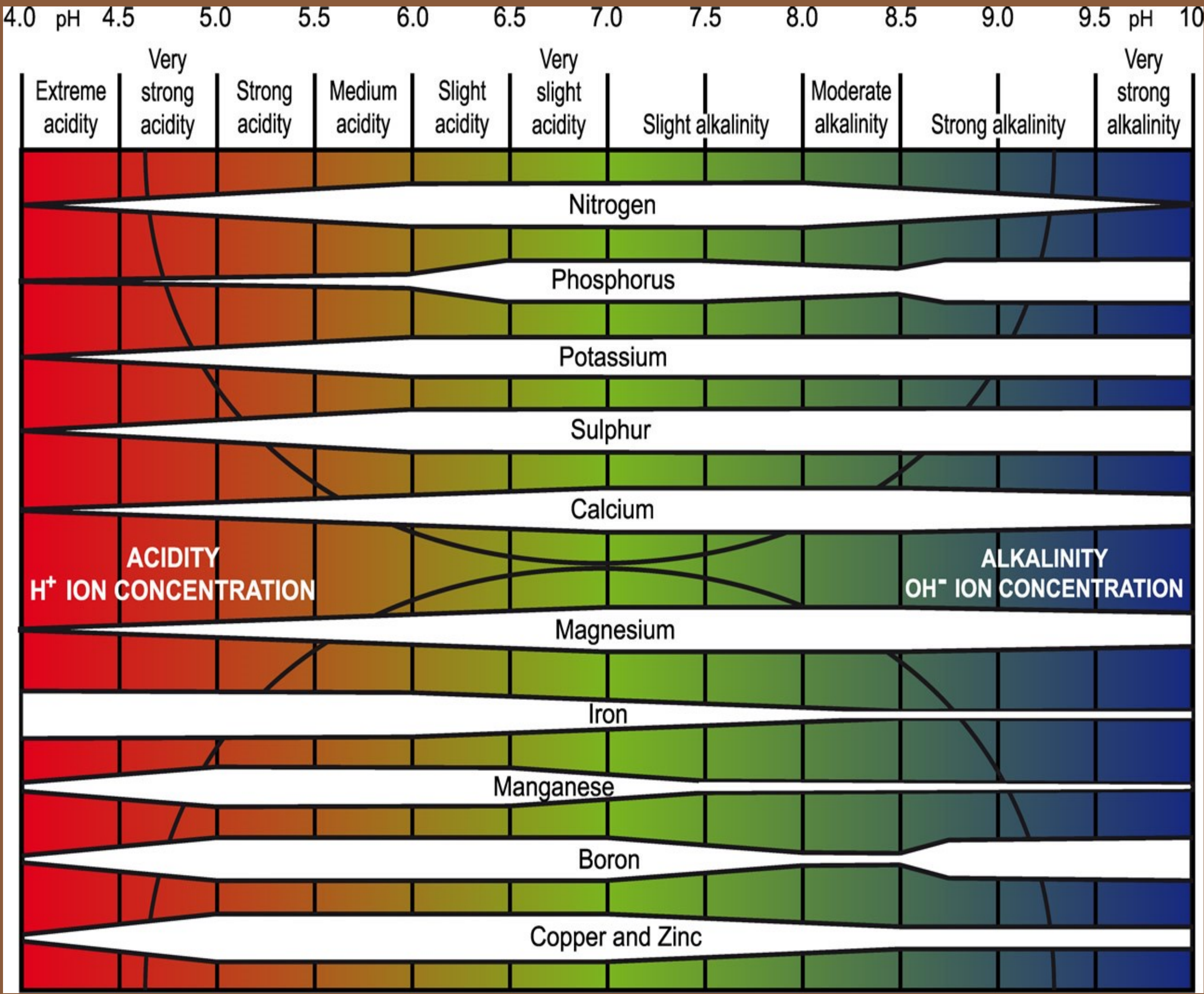
In plain words pH is about alkalinity and acidity. Soil with a pH below 7 is said to be acid; above 7, alkaline and about 7, neutral.

In more technical words, pH refers to the concentration of hydrogen ions in soil. The higher the concentration, the lower the pH and vise versa.

pH has an influence on the availability of nutrients to plants, amounts of nutrients held in soils, toxicities and microorganisms.

Knowing the pH of the soil will help with the choice of plants, although pH can be adjusted to suit a wider range, e.g. in a cropping situation.

As far as nutrient availability is concerned, a pH somewhere in the range 5.5 to 6.5 should be suitable for most plants.



PH AND MICROORGANISMS

All microorganisms have a pH range in which they survive and grow best. Outside that range they survive but they do poorly. Bacteria become less numerous as pH declines and fungi, which are slow composers, dominate at low pH. If a plant is weak through growing in soil with an unsuitable pH, it will be more susceptible to attack than if it were growing more vigorously. Changing pH can then indirectly help prevent or control disease.

TESTING AND ADAPTING SOIL PH

For starters we need to know the soil pH which can be easily identified with a test kit. The methods of how these are used differ with brands.

Adapting the pH of the soil does not automatically mean an ample supply of nutrients. If a soil contains little of an element, no amount of pH change will improve supply enough for good plant growth.

On the other hand, if a soil contains a large amount of a nutrient, it may still supply enough at what appears to be an unfavourable pH.

More often soil needs to be made more alkaline, rather than acidic and this can be done with lime, dolomite and occasionally calcite. Lime (calcium carbonate) supplies soil that is too acidic with Calcium and Magnesium and improves the availability of other elements.

The most commonly used acidifier is Sulfur, which microorganisms convert into sulfuric acid.

Changing the pH either way, will take time and the amounts to use depend on the soil type and existing pH.

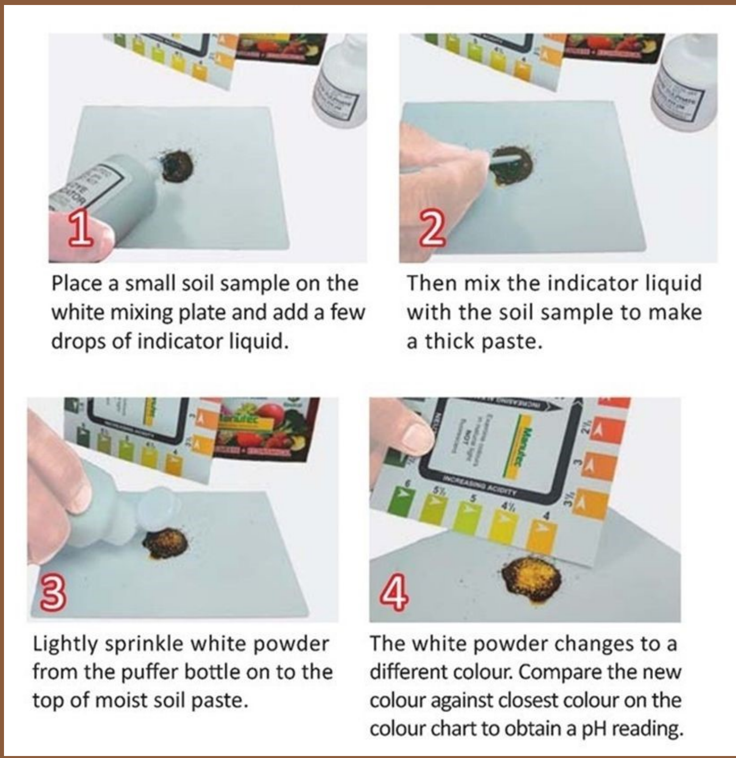


Image: Testing a soil sample for its pH, Source: soilphtesting.com

PLANT NUTRIENTS

All plants need at least 16 elements to survive and some need others for best growth. These elements are taken up by the leaves (carbon, hydrogen and oxygen) and by the roots (water, oxygen and other elements).

Nutrients enter plant roots as ions that come from the water around their roots. As ions are removed from this water, they may be replaced by others from:

- colloid surfaces
- decomposition of organic matter
- decomposition of minerals
- solid fertilizers
- additions in liquid feeds
- slow-release fertilizers

It is very important to know that most Australian soils are naturally deficient in nitrogen and phosphorus, which is ok as our native vegetation is perfectly adapted to it. However, most introduced plants prefer more available 'food' to be able to grow.

Depending on what plants are to be grown, fertilizers may be added to the soil for best growth. But if, for example, a fertilizer suitable for vegetables is added to soil around native vegetation, the Australian plants will die due to toxicity.

When planting native seedlings, it is a good idea to help them grow by using fertilizer, but only fertilizer that is suitable for Australian plants should be used. They usually come in form of solid or slow-release fertilizers to allow a gradual uptake of nutrients, rather than being bombarded.

Citrus and Blueberries like more acidic soil and therefore, fertilizer with their target nutrients are different again.

What happens if there is too much fertilizer in the soil? In simple terms, extra supplies become toxic and plant growth is reduced. On top of that, excess fertilizer that is not used is washed down into the water table and ends up in creeks, rivers and eventually, the sea.

This oversupply in waterways then causes algae to grow, which absorb oxygen from the water, in turn taking it away from plants, microorganisms and animals.

Therefore it is really important to be mindful of when and how to use fertilizers, making sure that the plants get what they need, but not oversupplying what plants cannot use.

SALINITY AND SODICITY

We hear more and more about problems with salinity and sodicity in soil. How comes that in the Barossa, we are so far away from the sea and have problems with salt in our soil?

Salts are combinations of electrically charge ions that separate from one another when a salt dissolves in water. Fertilizers contain salts in one form or another, releasing it when it dissolves in water.

But fertilizers are not the only cause of salinity or sodicity. Water in the sky forms droplets around dust particles (which contain salts), which rain down onto plants and the ground.

The water dissolves more salts from minerals. The sun evaporates the water and leaves the salt behind. More water is added, dissolving more salts hence raising the salinity.

Further down, salts that are actually washed down end up in the water table, where it is accessed by bores and pumped up to irrigate crops, creating a cycle of slowly increasing salinity.

This is the reason why salt content in bores at the end of summer is much higher than at the end of winter. Natural rainfall dilutes and washes away much of the salts during winter, but not in summer.

A low amount of salt is important for plant growth, but too much salt will be detrimental for plants. Ever tried watering a terrestrial plant with sea water?

Yes, there is sea plants that are perfectly adapted to salty water and even mangroves have found a way to get rid of excess salt through their leaves.

Image: Sodic soil, Source: regyp.com.au

The problem closer to home are actually sodic soils. Many soils in inland Australia are sodic because they have formed on old marine deposits. Irrigation can do the same thing, although more slowly.

Sodium (and lower amounts of calcium and magnesium) contained in irrigation water leads to deteriorating soil structure.

When wet, sodic soils are sticky and slippery and on drying, the mess of individual particles at the surface forms are crust which seedlings find hard to penetrate. On slopes, sodic soils erode easily, subsurface tunnels form, then huge gullies.

Three types of water have especially high concentrations of sodium:

- Laundry effluent waters containing detergent powder. Liquid detergents are much less hazardous.
- Water softeners
- Swimming pool water

COPING WITH SALINITY AND SODICITY

Managing the effects of salinity and sodicity can be done by reducing evaporation, growing salt-tolerant plants, using fertilizers wisely, applying gypsum to improve the soil structure and drainage (especially in clay soils), acidifying a soil and careful irrigation.

Using fertilizers wisely

All fertilizers increase the salinity and applying it wisely will help manage effects of salinity and sodicity.

- Making sure that the soil is moist before application
- Allowing plant leaves to dry before application
- Applying fertilizer at the recommended rate
- Irrigate immediately after fertilizing
- Apply less than the recommended rate if these precautions are not possible

Image: Different fertilizers, Source: eirich.com

Gypsum

Gypsum is the most commonly used material used to improve sodic soils. It helps the fine particles to form crumbs, improving the soil structure.

Image: Gypsum, Source: regyp.com.au

Removing salts

The only way to remove salts is to wash them out with plenty of fresh water, but it is only possible if water can drain fairly quickly down through the soil, out of reach of roots. This may include installing drainage for poor structured soils or the application of a source of calcium.

Method of irrigation

- light, frequent sprinkling is useless as the salts accumulate in high concentrations in the surface few centimetres of soil, soon reaching toxic levels there. Irrigate infrequently but deeply.
- Low-throw sprinklers keep wetting of leaves and their salt uptake to a minimum. They also allow less evaporation.
- Drippers reduce evaporation even further and keeping them running during summer rain prevents salts from moving back from the edge of the wetted zone into the root zone.

Image: Drip irrigation, Source: dripworks.com

The removal of deep rooted trees has led to rising ground water levels which bring up salts from deep in the subsoil to the surface in lower parts of the landscape. Replanting trees will help combat salinity in the future.

WATERING

Plants are lazy and use the water that is easiest available. If watering is done frequently but shallow, the roots will be in the zone that is moistened, but if it is done infrequently and deep, roots are forced to grow deeper into the profile and extract water from there. This will make them less susceptible during dry periods.

Watering can be done too much:

- loss of nutrients can be large if soluble fertilizers are the main source. Slow-release fertilizers keep loss to a minimum.
- plants can be more susceptible to pests and diseases, e.g. root-rotting fungi.
- Water is wasted.

too little:

- plant death due to dehydration
- poor fruit set in fruit trees
- poor quality in vegetables

Observation is key to the right amount of watering. Learning the signs of when plants are stressed, but also watering at the right time.

- Match water applications to the level of growth needed
- Water infrequently and deeply
- Avoid watering in the heat of the day as most water will simply evaporate
- Avoid watering in the evening as the remaining water encourages fungi
- Whenever possible, water in the morning
- Mulching is a great way to reduce evaporation
- Extra water is needed for leaching when the water used is saline. Saline water applied on a hot windy day can kill plant leaves
- Plants receiving a balanced supply of nutrients produce more growth per unit of water applied than those that are less well fed. They may use a little more water, but for each litre of water used they may produce as much as twice the growth.
- Weeds use water too, so removing them makes more water available for the plants you want to grow
- Grow drought-tolerant plants. Local native plants are adapted to the landscape and weather pattern.
- Under natural conditions, regeneration of shrubs and trees takes place mainly in wet years. Be prepared to water even drought-tolerant plants in the first couple of years.

A great way to measure the moisture in the soil is purchasing a moisture metre. They don't cost much and help determine how wet the soil is in what depths.

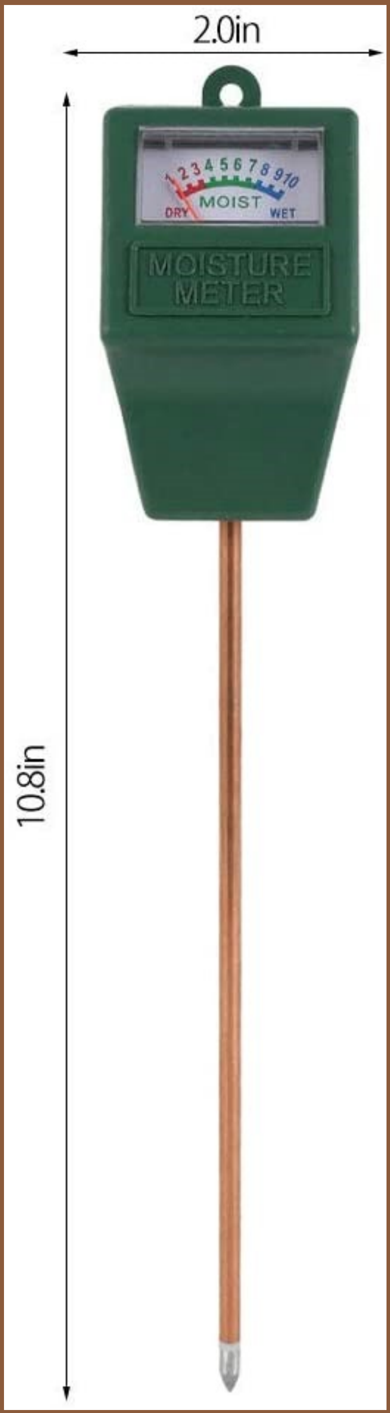


Image: Soil Moisture Meter

Testing the salinity of water

The salinity in water is measured with conductivity meters. It measures the conductivity of the water by sending an electrical current between two electrodes. The higher the conductivity, the higher the salt content.

NITROGEN FIXATION OR

BIOLOGICAL NITROGEN FIXATION

All plants require nitrogen to grow. Nitrogen is represented with the letter N on a bag of fertiliser.

Nitrogen plays an important role in plant growth and health and is essential for the process of developing chlorophyll, which promotes lush green growth, large leaves and thick stems.

The air that surrounds as is made up of 78% of nitrogen but plants are unable to use this form of nitrogen. Plants need to covert it before they can use it.

This process is called nitrogen fixation or sometimes called biological nitrogen fixation (organic, a natural process). Some plants like peas, beans and acacias, which we call legumes, have a symbiotic relationship with a bacteria called rhizobia. Rhizobia is the main bacteria but there are other nitrogen fixing bacteria as well. The rhizobia covert the nitrogen from the air thought the nodules they have attached to plant roots. The plant is then able to use the nitrogen - put in simple terms.

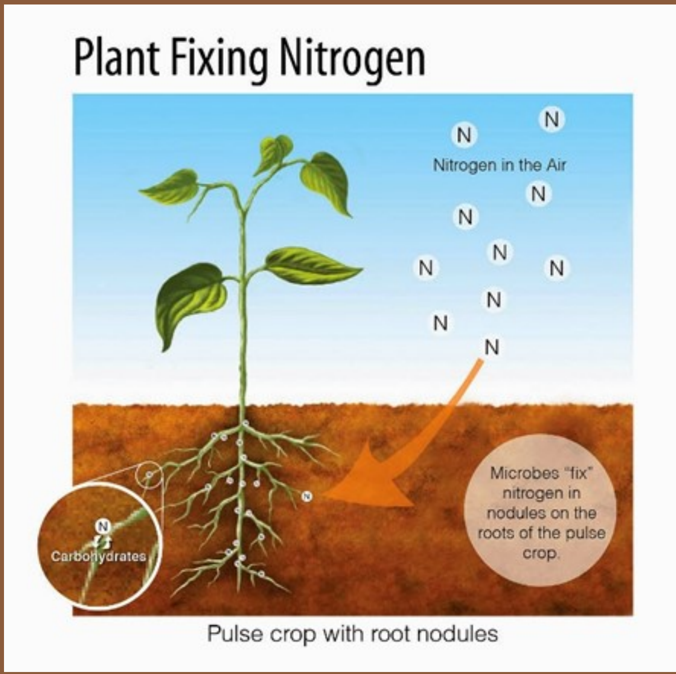


Image: A legume plant root showing nodules attached to the roots, Source: https://aces.nmsu.edu/pubs/_a/A129/

NITROGEN FIXING PLANTS

Legumes are plants in the family Leguminosae and these are some commonly known legumes plants.

Peas
Beans
Clover

Plus the following natives (not a complete list).

Acacia acinacea	Gold Dust Wattle
Acacia agryophylla	Silver Mulga
Acacia calamifolia	Wallowa
Acacia continua	Thorn Wattle
Acacia euthycarpa	Wallowa
Acacia melanoxlyn	Blackwood Wattle
Acacia myrtifolia	Myrtle Wattle
Acacia notabalis	Stiff Golden Wattle
Acacia oswaldii	Oswald's Wattle
Acacia paradoxa	Kangaroo Thorn Wattle
Acacia pycnantha	Golden Wattle
Acacia retinodes	Swamp Wattle
Acacia rigens	Needlebush Wattle
Cullen australasicum	Native Scurf-pea
Daviesia brevifolia	Leafless Bitter-pea
Daviesia ulicifolia	Gorse Bitter -pea
Dillwynia hispida	Downy Parrot-pea
Eutaxia diffusa	Spreading Eutaxia
Eutaxia microphylla	Mallee Bush-pea
Hardenbergia violacea	Native Lilac
Hardenbergia violacea pink	Native Lilac
Hardenbergia violacea white	Native Lilac
Platylobium obtusangalum	
Senna artemisioides ssp coriacea	Punty Bush, Senna
Senna artemisioides ssp petiolaris	Punty Bush, Senna
Glycine caldestina var. sericea	
Kennedia prostrata	Running Postman
Lotus australis	Australian Trefoil

Photo: *Allocasuarina verticilata,* Source: Pam Payne

Photo: *Allocasuarina pusilla,* Source: Pam Payne

Other nitrogen fixing plants

The main native plants that are nitrogen fixing belong in the Casuarinaceae family, that being Casuarina's and Allocasuaria's commonly known as she-oaks, or Bull oaks.

Allocasuarina muelleriana	Slaty Oak-bush
Allocasuarina pusilla	Dwarf She-oak
Allocasuarina verticillata	Drooping She-oak

NITROGEN FIXATION OR
BIOLOGICAL NITROGEN FIXATION

How to use nitrogen fixing native plants in your gardens

Plant a hedge of plants around your vegie garden e.g. small herb or shrubs. This not only adds nitrogen to the vegie garden, they also attract native bees and other beneficial insects as well.

Campion planting

Plant nitrogen fixing plants with fruit trees. This will give the fruit tree a supply of nitrogen and will also invite native bees and insect to your orchard.

Plant a shrub like:

Kennedia prostrata	Running Postman
Eutaxia diffusa	Spreading Eutaxia
Eutaxia microphylla	Mallee Bush-pea
Acacia acinacea	*Gold Dust Wattle*
Acacia myrtifolia	*Myrtle Wattle*
Acacia notabalis	*Stiff Golden Wattle*
Allocasuarina pusilla	*Dwarf She-oak*
Hardenbergia violaceae	*Native Lilac*

Inter-planting

Inter planting plants that provide nitrogen in between fruit trees, nuts and citrus tree.

Acacia melanoxlyn	Blackwood Wattle
Acacia pycnantha	Golden Wattle
Acacia retinodes	Swamp Wattle
Senna artemisioides ssp coriacea	Punty bush
Senna artemisioides ssp petiolaris	Punty bush
Allocasuarina verticillata	Drooping She-oak

Photo: *Hardenbergia violacea* Native Lilac, Source: Pam Payne

Photo: *Senna artemisioides ssp coriacea* Punty Bush, Senna, Source: Pam Payne

References:

Agriculture Victoria, 2020 - *What is Soil Health?*
http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_what_is

Bonney, N., 2016 - *Sheoaks (Casuarinas) - Wind Harps from Desert to the Sea*, Tantanoola: Neville Bonney, ISBN 9780 6469 6037 1

Earth observing systems, 2021 - *Nitrogen Fixation: N-Fixing Plants & Bacteria, Their Importance*.
eos.com/blog/nitrogen-fixation/

K. Handreck and N. Black, 1984, *Growing Media*, New South Wales University Press, ISBN 0868 4017 73

"NMSU: Nitrogen Fixation by Legumes." Nmsu.edu, 2013,
aces.nmsu.edu/pubs/_a/A129/

"Plant Life: Nitrogen Fixation." Plant Life,
lifeofplant.blogspot.com/2011/03/nitrogen-fixation.html

Reece, J.B., Meyers, N., Urry, L.A., Cain, M.L., Steven Alexander Wasserman, Minorsky, P.V., Jackson, R.B., Cooke, B. and Campbell, N.A., 2015 - *Campbell biology*, Melboune, Victoria: Pearson Australia, ISBN 9781 4886 1371 5

World Flora Online, 2021
http://www.worldfloraonline.org

Barossa Bushgardens

653 Research Road

Nuriootpa SA 5355

(08) 8563 8330

bushgardens@barossa.sa.gov.au

www.barossabushgardens.com.au

Opening hours:

Monday and Friday by appointment

Tuesday & Thursday

9 am - 4 pm

Wednesday

9 am - 12.30 pm

Saturday and Sunday closed

The Barossa Council

LANDSCAPE SOUTH AUSTRALIA NORTHERN AND YORKE