Soil biology the key

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Soil biology is the key - my aim with WickiMix is to provide a concentrate and inoculant where people can create their own healthy soil form what would otherwise be waste. It is only needed in small quantities to avoid excessive transport costs.

The three key elements of soil are the chemistry, the physics and the biology. These are interrelated but here I look at how these areas affect the creation of wicking bed soil.

Part 1 Chemistry and nutrition of wicking beds

Nutrition

One of my early failures with wicking beds (unfortunately one of many failures but that's how you learn) was over nutrition.

I fed my bed a very dilute worm juice mix every day and it worked wonders. The plants were really growing vigorously and all looked good. Then one morning I found that the entire box had keeled over and died. With the wonders of hindsight (great stuff hindsight) it was clear what had happened.

In a normal garden there is continuous flushing so the nutrient concentration stays constant. By contrast in a wicking bed there is little or no flushing (or should be) so any nutrient you add stays in the bed until used by the plants - but evaporation and transpiration still occur - so it is easy to add more nutrients than the plants are using. The result was a slow but steady increase in the concentration of the nutrient level in the water.

Roots absorb water by osmosis which is the principle that water will always flow from the weaker solution to the stronger. If the concentration in the roots is higher than in the surrounding soil the water will flow into the root system.

Conversely if the water surrounding the root has a higher concentration then water will literally be pulled out of the plants and it will die.

I was aware of this effect as from time to time gardeners will kill plants with too strong a fertiliser - I had not expected how quick and dramatic the effects could be in a wicking bed.

The moral is to be very careful with nutrient levels particularly liquid fertilisers added routinely.

I am a great believer in recycling and composting and in my experience there is little need to add the primary elements N,K,P in a wicking bed other than a little manure pellets which I use very sparingly.

However compost may be low in some of the secondary minerals such calcium, magnesium zinc etc. (See November Newsletter www.waterright.com.au). Calcium is particularly important for soil biology so I am generous with soil additives like gypsum and dolomite.

Generally compost made from modern food waste is low in the critical trace elements selenium is a classic example which is needed for DNA production. However many of these trace elements are toxic at higher concentrations and we only need these in very small quantities - we are talking micrograms. I therefore add these trace elements in very small quantities to my soils.

Part 2 Soil Physics

The successful operation of Wicking Beds depends on soil physics, particular the surface chemistry and size of the soil particles.

Hydrophobic and hydrophilic soils

Most people are familiar with soils which appear to soak up water while others, such as a sandy soil with gum leaves will not wet so the water sits as little droplets on the surface.

All soils benefit from being hydrophilic or water loving but in wicking bed it is critical to have a soil which is water-loving - that's how wicking beds work.

It is important to select components in the soil which are naturally hydrophilic but the performance can be increased significantly by soil biology.

Particle size

Capillary action work with size - the finer the capillary the greater the greater the wicking force. However the finer the capillary the higher the resistance to flow.

For example clay has extremely fine particle size and therefore generates very high capillary forces - so far so good - but the resistance of water movement through the clay can be so high that there is simply not enough flow to supply the plant with water.

Conversely stones have virtually no wicking action so will never feed the plant by wicking action. (They may appear to work by a process of evaporation and condensation or the roots simply penetrating the stones to suck the water up directly) but they simply do not wick.

I aim for a particle size of between 0.2 and 0.5mm which seems a reasonable compromise. However soil biology can create a surface chemistry which makes fine particles clumps together in aggregates to give that magical property that all gardeners aim for - tilth.

Void space

One of the purposes of a wicking bed is to conserve water and extend the time between watering. (I actually think that preventing the waste of nutrients beyond the roots zone is more important.)

Some designs of wicking bed have a separate external water container connected to the soil by some form of wick. This is fine for smaller manufactured pots but it not suitable for larger beds so most people use some form of internal water storage. A common method is to use stones covered with a layer of cloth - another method which I prefer is to use soils which have been developed to have a very high water holding capacity.

To emphasise the point I am not talking about just shovelling a load of garden soil into a wicking bed but developing soils specifically for wicking beds with a very high water holding capacity.

Don't talk measure

There is a lot of debate about which is best - stones or soils - and both system work but the debate is best settled by measurement not theoretical debate.

It easy to measure, just take a container of known volume (weigh it full of water to get volume) then load it with dry soil (actually at wilt point), weigh it, then fill with water until totally saturated and weigh again. The increase in weight as a % of original volume is the void content of the soil.

An experiment like this would quickly show that if you simply dug up heavy soil straight out of the garden it is likely to have poor water holding capacity.

The stone and cloth system stones system is much better than heavy clay however stones have virtually no wicking although sand can have similar water holding capacity and wicks quite well.

However the best results are obtained with a well formulated soil.

Soils for the water reservoir

I have measured up to 60% void in some of my best soils. This is higher than you would get with sand or stones. However it is more complicated than that.

Water is stored in the gaps between the particles; the amount is fixed by the geometry and packing of the soil particles. The void left with spheres is theoretically between 30 and 50% depending on how they pack. The void space does not depend on particle size.

If the particles are irregular in shape they do not pack closely giving a higher water holding capacity. If there is a range of particle sizes the water holding capacity is reduced as the smaller particles fill in the holes between the larger particles.

In general stones have a marginally higher water holding capacity than sand but sand had a much higher wicking capacity.

Voids and absorption

However in addition to the space between the particles water can be held inside the particles for example with minerals such as vermiculite, pearlite, zeolite etc. and organic materials such as coconut fibre or for that matter most organic material. Roots are my particular favourite as they can also introduce beneficial soil biology.

Some minerals such as vermiculite, perlite and zeolite absorb a lot of water internally (they are highly porous) and have irregular shaped particles so the water holding capacity is very high - approaching 100% almost as good as you get with a separate reservoir.

However there is a snag (as usual with things that sound too good to be true). These highly absorbent materials just love to hang onto the water. Wicking is a tug of war between

competing surfaces so although there may be plenty of water it simply sits there and does not wick out so they effective water holding capacity is not as high as expected.

Cavalry to the rescue - here come the roots

However plants have a sophisticated method of capturing and transporting water. The roots pick up the water by osmosis in which water moves from weaker to stronger solutions, then wicking action helps the water move and finally the attraction of one water molecule to another literally pulls the water up the plant as water evaporates from the leaves. There is no way that wicking could pull water to the top of a twenty metre tree.

If roots are encouraged to extend over the entire volume they will extract water otherwise locked up inside these porous materials. Roots can easily penetrate the soil to extract all available water.

Good soil is full of voids, obviously a solid clay would not be good but if you get the soil right with organic material, worms (which make holes through the soil) and additives like vermiculite, perlite or better still organic material like decaying roots then soils can have a very large void capacity.

80% sure

Conventional wisdom says that plants will die if the roots are totally submerged in water (except for specialist plants like mangroves and rice). This is largely true and I use this principle when I submerge difficult to kill weeds and their seeds in water.

However I have done tests in which I had a water reservoir formed by a layer of cloth in a fish tank so I can watch what happened. The roots were tenacious and went straight through the cloth as though it was not there, entered the water reservoir and appeared to continue to grow and branch even though completely submerged.

The soil above was relatively dry and has a well-developed root system.

It appears that provided that there are some roots that have access to air that other parts of the root system can flourish even if submerged in water.

In science you are never 100% sure and assign a probability to being right. From a scientific viewpoint I have a conservative estimate that there is an 80% probability of this being true, however I am pragmatic and plants grow really well with the system so this is the way I grow my plants.

Part 3 soil biology

Soil biology is the most critical component of good soil, it releases nutrients so they are available to the plants and changes the surface physics to improve the wicking action and to enable individual soil particles to aggregate to form that tilth which all gardeners strive for.

Working in the area of soil chemistry and physics is comfortable as we have a very high understanding of the science. However we do not have that comfort with soil biology. As yet we have only identified and studied a small percentage of the organisms which are suspected of existing. We have only been able to identify, study and produce very few of the total number of species a commercial scale.

I have experimented with some of these commercial products and been somewhat disappointed.

I have also been alarmed by the American practise of sterilising the soil with methyl bromide (a highly toxic and poisonous chemical) then re-introducing known beneficial organisms. Do we really know enough?

In this state of ignorance it pragmatic to study and imitate how soil biology works in nature. After all nature have been developing viable eco systems for over a billion years.

I have learned from studying the natural process to create a root structure or rhizosphere which is full of biology (hopefully balanced with beneficial controlling the harmful) which I call WickiMix-R the R standing for rhizosphere. I use this as the lower layer in my wicking beds (and even in sponge and conventional beds).

Roots are a naturally absorbent material with a high water holding capacity. I prepare this rhizosphere as described in my November newsletter and use the root web as my absorbent layer which if full of active soil biology. Once established the biology will continue to reproduce in a sustainable (and free) way.

No free lunch

The arguments for an organic system are overwhelming but there is no such things as a free lunch so there are a couple of issues.

My original wicking beds which I made almost twenty years ago were just filled with ground litter (twigs and branches) and weeds.

The first issue is nitrogen drain resulting from this decomposition. This is easily solved with a bit of chicken manure but it is important not to over apply as I learned all those years ago. Fortunately for a home gardener the plants soon tell you if the concentration is wrong.

The second issue is the organic material will decompose with the soil level sinking so some way of topping up is needed. This can be done by using mulches or by having a top tray in which plants grow. This can be lifted and fresh organic material added directly to the lower layer.

This need for topping up is not a real problem and you should be adding extra nutrients on a regular basis anyway. If you take goodies out you have to put them back.