Keeping the Place Fertile (Organically)

www.underthechokotree.com
Sustainable Living in the Suburbs

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1.0 Introduction – The Fertiliser Review

One of the advantages of working in a team (even if it is just a team of 2!) is that the other members will have different perspectives and see things you don't. At our last director's meeting, Linda suggested that maybe we needed to review how we maintain the fertility of the soil. I thought "we do lots of things!" but I had never done a comprehensive review to see if we needed any changes. Needless to say, said fertility review went onto out list of things to do. And this is what came out of it!

This is a summary of what I have used, past and present to maintain our fertility while regularly get vegetable crops from the same ground (in some cases) for 40 years.

• **Animal manures** – prior to the start of our current system (about 20 years ago) the major type of fertilisation I used was the digging in of animal manures, mainly horse, cow and chicken bought in from local 'producers'. This was done in spring each year, but growing was concentrated in the spring and summer, with most crops dying off at the end of summer and nothing replanted until the following spring.

• **Chook tractor** – Once I found out about the chook tractor, and built one, it became our go-to for tilling and fertilising our veggie patches. Each of the 14 patches sees the chook tractor roughly once every 6 months for a period of two weeks. This process has been operating for 13 years and yields are still good (but maybe could be better). I have checked the pH in all beds recently and they all fall between 6.0 and 7.0 so the current fertilising system has not dropped the pH.

• **Mulch** – the mulch we use is straw or grass hay, broken down and mixed with chicken manure by the chooks in the chook 'retirement village'. The finished mulch is placed on most beds (not the onion or carrot beds) and left there until the chook tractor comes around again, at which point some of the mulch is buried and some remains on the surface to be mixed with the next load of mulch.

• **Biofert** – biofertiliser is actively aerated compost tea and is brewed for the biota (beneficial bacteria, fungi etc) it provides rather than to contribute chemical nutrition to the soil. I tried it a couple of times on several beds but didn't really notice much difference. During the hot summers, some beds awaiting the chook tractor tend to dry out a bit so contributions to improving the soil biota could be worth considering.

The Biofert reactor

• **Rock dust** – I applied rock dust a couple of years ago to all beds at the rate of roughly 50g per square metre to replace trace minerals which may not have been provided by anything else up to that point. Further research has suggested higher application rates up as far as 1 kilogram(!) per square metre. Further work needs to be done to identify the correct application rate for our situation, then all beds bought up to scratch again.

• **Dolomite** – when I was first developing the garden I applied dolomite (a mix of calcium and magnesium carbonates) to break the clay, add calcium and magnesium to the soil and bring the pH up slightly. I have not added anything like this for 20 years or more. We rarely have issues with tomato blossom end rot so I am guessing our calcium levels are ok at the moment.

• **Wood ash** – We get lots of wood ash from our wood burning stove and I save it up and have applied it haphazardly over the years, being mindful that it will raise the pH of the soil if I apply too much. The potassium it provides adds to the potassium in the chook poo, our primary fertilisation strategy. It has not appeared to raise the pH in any lasting way.

• **Biochar** – No data as yet. The wood ash mentioned above contains some charcoal, but whether it qualifies as biochar, how much is applied and how effective it is are all unknowns. I am currently researching biochar and intent to make a biochar stove to cook with outdoors at the same time as making biochar for addition to the gardens. We have made some using the slow combustion stove in winter, but more work to do there.

• **Compost** – We had two composters – areobins – that are up for their own review before long! That were reviewed and found wanting . We now have a three bin composting system (more detail later) which is working very well. I has provided sufficient compost for 5 of the annual veggie beds so far.

• **Comfrey extract** – We have a comfrey extractor which I fill with comfrey and sometimes nettles, apply a weight and allow it to rot down, catching the fertile liquid coming out the bottom. This is then diluted to the strength of weak tea and applied by watering can. It saw a lot of use, mainly on newly planted seedlings, when I first built it, but recently it has been so dry that the comfrey is just holding its own without trying to harvest leaves from it.

• **Weed/compost tea** – Similar sort of thing to the biofertiliser, but without the aeration. It is usually anaerobic and stinks. It is applied for its chemical trace elements rather than biota, diluted to the colour of weak tea, applied and watered in. I used it fairly indiscriminately in the past, but not recently.

• **Green manure** – This is where a mixture of plants, some nitrogen fixing, some grains and others are sown as part of a rotation, the slashed before flowering to be turned in or left as mulch. It increases the organic matter and fertility of the soil. Due to the way our rotation works, it would mean having a plot out of production for several months (depending on the time of year), then waiting for its turn with the chooks, who would eat most of the green matter anyway. I have played around with it on the annual wicking beds but it really does not suit our main veggie rotation very well.

• **Crop rotation** – simply expressed, this is just ensuring you don't plant the same crops (or crop family) in the same soil year after year. We do have a program of rotation which I am lousy at recording. A lot of our plots are used for an interplanted mix of vegetables such as sliver beet, lettuce and some brassicas year round, with seasonal plantings of salad vegetables such as tomato and cucumber and other vegetables such as fresh beans and zucchinis in summer and peas, caulis and broccoli in winter. We do plant whole plots down to one vegetable in cases such as carrots, onions, and dried beans. Working on better recording of rotations for later analysis seems like an intelligent thing to do.

• **Worm castings** – we produce our worm castings not for direct use from our worm bath, but these are entirely consumed in producing our own seed raising mix and potting mix.

Analysis

The way we have set things up, each patch should be treated separately, which is why I did a pH test on each individual patch rather than aggregating things into one effectively meaningless number. I would like to get a commercial soil test done on each

patch, but don't have the cash. Also while that would give me the chemical status it would tell me nothing of the soil biota.

So, in the end taking everything into account, it all comes back to how things grow in each of the patches, and of course the answer is that growth is variable and year on year some plants do better in some areas than others. This may be due to soil differences but also weather will have an effect too. Also, most gardeners will tell you that there is variability on how well crops grow for year to year anyway.

Where does this leave me? (actions)

Looking at what we are doing and were we are coming from, I am pleased with the yields we get in general, but there is always room for improvement, resulting in a number of actions.
I am a slacker, and not good at recording the fertilising status of each of our 14 beds so the first two (general) actions are –
1. Develop a record where I can commit to paper what sort of fertiliser should be going where and when (Fertiliser log) and
2. Develop a fertiliser program so that I can work out and then formalise what fertiliser needs to go where and when (fertiliser program)
There are also a number of specific actions that need to be carried once the first two have been done –
1. It can get very hot and dry here and I suspect that there are times when the soil biota may suffer, so I will put together a larger biofertiliser system which will allow me to apply biofertiliser to all 14 patches at one time rather than piecemeal.
2. The application rate of rock dust to replace trace elements may not have been adequate, so I will research the correct application rate, then apply it as each bed becomes free, after the chooks have cleared it but before it is mulched and replanted.
3. I feel that biochar may have positive things to recommend making it part of our fertiliser regime, so more research and activities need to be carried out.

2.0 Testing Your Soil

2.1 Soil sampling

There is a truism that says you can grow almost any plant in almost any soil; but the more fertile your soil is, the better the structure is and the more abundant the soil life is, the less you have to do to it to grow abundant fruit and vegetables. If your soil is so important to the growing process it seems to me that any information that you can glean about your soil will be worthwhile. By understanding your soil you can use techniques and additives that improve your soil over time rather than depleting it .

There are three aspects of the soil that can be investigated to help understand the soil we will be planting into –

Physical aspects – the type of soil and the constituents that go to make it up, which has an impact on soil structure, drainage etc.

Chemical aspects – how acid or alkaline the soil is and what sort of nutrient levels are present, which can impact how well any plants will grow can also affect the living organisms present in the soil.

Biological Aspects – what types of animal life can be found in your soil, which is also an indication of soil health.

I have used some tests that a “backyarder” such as myself can carry out where you do not need a PhD in soil science or the services of a fully staffed analytical laboratory, which is handy seeing as I have neither. Hopefully you can also use these tests to get a handle on how healthy or otherwise your soil is and use the results to plan on how you can improve your soil in the long term. Also, for those of a Permaculture persuasion, this can be some interesting research to carry out before you develop your Permaculture design.

If you are sampling your soil before putting in a veggie patch or some fruit trees it is a

good idea to do your sampling a few months before you plan to start work, that way you get time to make adjustments if you find something out of kilter. It is a good idea to sample and test your growing areas every few years too, so you can keep a handle on how your soil is going. The actual time of year doesn't matter so much but if you have disturbed the area, say by double digging a veggie bed, it would be best to let things settle down for a month or two before sampling.

Sampling your soil

In the same way that a chain is only as strong as its weakest link, your soil testing result is only as good as the samples you have taken. Take enough and combine them well to form homogenous soil mix and your testing regime will be reasonably accurate. Do a crap job of sampling and your results will be skewed, so any decisions taken on the basis of those results will be crap too. It is the classic data cliché – garbage in = garbage out. So it is worth getting this step right!

The first thing is to look at your yard and where you intend to grow your fruit, veg and herbs, to identify the areas you wish to test. In our case we have three "blocks" of veggie patches we grow things in (plus a single patch over by the northern fence), and there are also a number of fruit tree growing areas too. To facilitate this, a map of the area you are going to sample will come in handy, even a hand drawn mud map will help.

What you will need

- A clean spade or trowel (while it doesn't matter for the purposes of this exercise, if you think you might want a full, professional analysis done on your samples at some later stage, do not use brass or galvanised tools to take the samples, it will give a falsely high reading on copper or zinc)
- A bucket (plastic works well here, a galvanised one may cause obvious problems)
- Pen & Paper (for any notes) and a clip board really helps!
- Your mud Map.
- Plastic bags – large, resealable and felt tip pen for labelling

Look over the area you wish to sample and then mark out where you are going to take your samples using a zigzag pattern, working from one side of the area to the other with the sample areas about a metre apart. For most backyard veggie growing areas 5 or 6 samples would be plenty. The sample depth should be as follows:

- Usual veggie garden type areas – 100 to 150mm
- Shrub areas like some larger herbs or berry bushes – 150 to 200mm
- Trees such as fruit or nut trees – 100 to 200mm

Taking the samples

Brush away any mulch or vegetation on top of the soil before taking a sub-sample. Using your spade or trowel, dig a vee shaped hole down to the required depth. Place the spade or trowel near the edge of the hole at about 1 centimetre away. Push down steadily so that you cut a 1 cm slice from the ground level all the way down to your sample depth. Pick up the slice and dump it into your bucket. Move to the next sample area and repeat the process until all areas have been sampled.

Using your hand, break up any soil lumps and then scoop the soil around in the bucket to ensure it is well mixed. If there has been rain and the soil is a bit muddy you may need to let the sample dry out a bit, do this by spreading it out on clean paper out of the sun and let it air dry naturally for a few hours. Alternatively, sample after the soil has had time to dry out a bit.

Once you are happy with your sample, place it into the plastic bag. If you have more than one sample don't forget to label each one and then mark on your mud map where the samples were taken.

Recording

As well as marking your soil sample points on your mud map, it is handy to keep a tally of what samples have been taken where and when, what tests have been done on them and what the results of the tests were. One way to do this is to fill out the Soil Test Results Sheet, available as Appendix 1**.** This will help you keep a running tally of where you are at with your soil testing program and provide a handy summary to be reviewed when you are making decisions about soil improvements. If you are doing this for somebody else it also acts as a useful one page report that you can give them.

2.2 Soil Testing - Physical Aspects

The physical aspects of a soil consist of how its parts work together to form the soil structure, dictating how well or otherwise a given plant will thrive on that soil. Soil is generally broken down into three physical components; Sand; silt and clay but you can also add a fourth – organic matter.

Sand – a sandy soils, like those found around Perth (Aus) have very coarse structure with good drainage but a sandy soil lacks clay and loam and so will not hold water and will tend to lack nutrients. Sandy soils are easy to dig into and plant roots can penetrate them easily but dry out quickly after rain. Too much sand can be as bad as not enough.

Clay – on the other hand, clay soils have very fine particle size, they generally can provide the plant with good nutrition, but drainage is poor and they tend to waterlog easily. There is nothing like planting into good old Sydney clay! Unfortunately, when the clay soil does dry out it can go hard as a rock and be very difficult for plant roots to penetrate and a bugger to have to dig.

Silt (often referred to as "Loam") – silt is weathered rock and in particle size sits between sand and clay. It feels like flour when dry but has a silky feel when wet. It provides some nutrients to plants and allows for some soil water retention.

There is a complicated little **phase diagram** which, once you know the percentages of each of these three components, will allow you to work out what type of soil you have. It might be clay, clay loam, sandy loam etc. To me the name is fairly meaningless because I am a back yarder not a soil scientist, but the components of my soil will let me know how well I will be able to grow the plants I want but also give me some hints on what I can do to improve my soil.

Organic matter – This is the part of the soil contributed by the plants and animals which live in, under and on top of the soil. It is comprised of humus, particulate matter like mulched up sticks and leaves or partially decomposed animal dung and, especially where bushfires are a feature of the landscape, charcoal. Strangely enough soil organic matter not only improves drainage but also improves soil moisture retention, as well as providing nutrients for plants and other soil life.

Conducting the Test

It would seem a good thing to have a rough idea about the sort of soil you are blessed (cursed?) with and what you can do about improving it, so what follows is a simple test anyone can carry out once you have correctly sampled your soil.

1. Get hold of some glass jars, somewhere between 500ml and 1 litres (I use recycled 500ml jars because it is what I have). You will need to have one jar per soil sample (see soil sampling). If you use recycled jars remove the labels, you will need to be able to look through the side of the jar and it is easiest to compare relative amounts of the soil components if the jar has parallel sides.

2. Label each jar so you know which sample is in it, I just use a simple number to denote which is which but it is a good idea to write down somewhere what each number means. A good place to do that is the soil test results sheet.

3. Add a soil sample of approximately a quarter of the volume of the jar, I use 500ml jars so to put the sample in I used a half-cup sized measuring cup (1/2 cup = 125mls).

4. Add water up to approximately 80% of the volume and then place on the lid (firmly!) and then give the whole apparatus a good shake. A loose lid lets it gush out all over the place and if you happen to be doing it in the kitchen and the lid comes off your popularity score with your significant other could take a considerable dive. (not that that happened to me of course!)

5. Let the samples stand unmolested overnight and they will be ready to read the next morning.

This process works by stratification, the heaviest materials sink quickest, while the finer materials can take much longer to settle. So over time a series of layers are laid down and these can be read through the side of the glass jar. The bottom layers will consist of any rocks, followed by coarse sand, fine sand, silt and then progressively finer particles

until the clay layer deposits, although the really fine clay may take days or weeks to come out of suspension.

Another indicator of the type of soil you have to work with is the layer of floating material on top of the water. This layer is formed by the soil organic matter, so the thicker the layer the more organic matter in the soil.

The relative thickness of each layer will give you an idea of how your soil is made up. A quickly sinking thick layer of coarse material indicates a very sandy soil whereas rough equal amounts of all components indicates a good loamy soil that won't take much effort to grow plants well.

"Feel" Test

There is an even quicker and lower tech soil test which requires no equipment and can be carried out in the field. Dig down with your fingers into the soil and make a ball of soil and squash it between your fingers, smear it about a bit. How does it feel?

If the texture has a “silky” feel to it your soil will have a high clay content but on the other hand if it has a “gritty” feel it will be a predominantly sand containing soil.

Altering Your Soil

Regardless of the soil you are working with you can improve it, or you can make it worse. To improve a sandy soil, add organic matter in the form of compost and mulch it well. This will both provide nutrients for the plants and improve the soil’s capacity to hold water.

If you already have a silty/loamy soil you probably won’t need to do much, but every soil is improved by adding organic matter so you may want to add some to ensure nutrient levels remain high. Depending on your climate, mulching usually improves things too although in a very wet climate it can cause too much water retention.

If you have a clay soil there are additions which you can make that will directly improve drainage and soil structure. Fine clays are sodium clays and while they are nutritionally good for the plants they tend to get waterlogged very easily. To overcome this adding a source of calcium will cause a chemical reaction which changes the clay from being a sodium clay to being calcium clay which has a much more open texture and much better drainage. To achieve this either add powdered gypsum (a mineral) which is neutral and will not affect soil pH or, if the soils are acid add either agricultural lime (calcium carbonate) or dolomite (a mix of calcium and magnesium carbonates) which will raise the pH, making the soil less acid.

Unfortunately it is also possible to alter your soil for the worse and this will occur if it is cultivated too much. Cultivating the soil by digging, double digging or rotary hoeing breaks down the soil structure reducing drainage and air penetration into the soil. It also has other undesirable effects such as reducing the amount of living things in the soil and exposing organic matter to the air and sun where it can be oxidised or “burned out” of the soil. The more often the soil is cultivated and the more aggressively it is cultivated eg by a rotary hoe rather than a spade, the more marked this effect will be.

2.3 Soil Testing - Chemical Aspects

When it comes to the chemical aspects of your soil which you can test yourself, it usually boils down to three facets, pH, soil nutrients, particularly the major nutrients nitrogen, phosphorous and potassium (NPK) and salinity.

pH

The pH of the soil refers to how acid or alkaline the soil is, which can have a significant impact on plant nutrient uptake and subsequently plant health. There is a fairly simple qualitative test that you can use with stuff you probably have hanging around your house –

Acidity test – put a dessert spoon of the soil you wish to test into a cup. Add ¼ cup of water then sprinkle over some sodium bicarbonate (baking soda) and mix in. If you get bubbles, ie the sample fizzes, your soil is quite acid.

Alkalinity test – put a dessert spoon of soil into a cup then add a dessert spoon of vinegar and mix. Again, if you get fizzing then your soil is alkaline.

This is a pretty simple test which you can do quickly, cheaply and easily but it does not give you a number so to be really sure of what pH you soil is, it is best to pick up a soil test kit and use that.

Soil Nutrients

There is no simple home developed test for NPK but there is a test kit you can get which will allow you to test for these nutrients as well as pH. The process is similar for all the tests and involves taking a soil sample of 1-2 grams then place into a plastic tube (part of the kit) and add a similar amount of water. Filtering the solution by forcing an inner tube inside the outer tube so that a soil solution is forced through a replaceable filter on the bottom of the inner tube. Into the filtered solution is then added a measured amount of chemical reagent(s) and the solution left to develop a colour or level of opacity which is then read against a chart supplied with the kit.

While not providing a number as such, it does give you a readout against a scale from "very low" to "very high". It is easy to see, once all the tests are done, if you have a nutrient imbalance and get a general idea of the nutrient status of the soil for the macronutrients at least.

There are soil nitrate meters available which can give you a direct readout of your soils' nitrate content in the same way a pH meter gives you a direct reading of soil pH but they are expensive. They cost hundreds of dollars (up to $600) and they require regular calibration using a calibrating solution which has to be bought as well. The other alternative is to submit samples to a soil testing laboratory who can not only conduct a battery of tests but also provide a report to help you interpret the results of the tests.

If it is clear that there is a nutrient lack or imbalance, information on recovering the situation is available in Section 4.0

Salinity

The term soil salinity refers to how much salt is present in the soil and this is one of those cases where the less there is, the better it is for the plants. Salt in the soil results in loss of soil structure, loss of soil porosity, reduced water and air movement through the soil, reduced ability by the plants to take up water and nutrients.

Salinity is usually tested using a soil conductivity meter, the principle being that the greater the salt level the greater the conductivity of a soil solution. These meters cost from $200 up to over $1000 so unless you are really enthusiastic the cost may be a problem. Even low cost meters can have other functions though such as being able to read pH as well. In general terms, to use a salinity meter requires you to take a soil sample, dry it, mix a measured amount of soil with a measured amount of distilled water and take reading. The reading must them be multiplied by a factor taking into

account the type of soil being measured which converts the result into a number which can be compared against a scale to enable the result to be interpreted.

There is another way to check if you have a salt problem, by looking at what is happening with the veggies you are growing. Salt levels that are high enough to cause a problem generally manifest themselves in one or more of the following symptoms –

- sudden wilting,
- stunted growth,
- marginal burn on leaves (especially lower, older leaves),
- leaf yellowing,
- unusual leaf fall,
- dead roots,
- restricted root development,
- sudden or gradual death of plants

Two factors that may modify a plant's reaction to salty soil are high rainfall, which washes the salt downward in the soil profile out of the root zone and high temperatures and low humidity which dry the soil out, concentrating the salt and making its effects worse.

Response of all veggies to a given salt level is not the same, some are tolerant and some are less so, see the list below –

Salt Sensitive Vegetables

Beans, carrot, onions, parsnips, peas

Moderately Salt Sensitive Vegetables

Broccoli, brussel sprouts, cabbage, capsicum, cauliflower, celery, cucumber, eggplant, lettuce, potato, pumpkin, radish, spinach, sweet corn, sweet potato, tomato, turnip, watermelon

Moderately Salt Tolerant Vegetables

Beetroot, button squash, zucchini

Salt Tolerant Vegetables

Asparagus

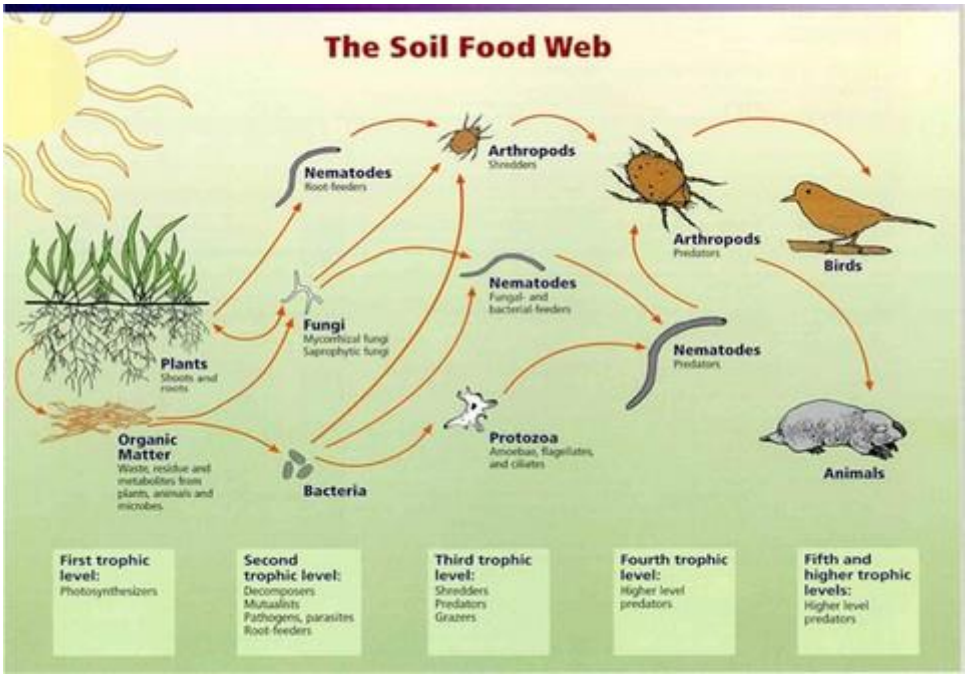
If you are getting the plant symptoms mentioned above it could be worthwhile looking at the types of veggies most affected, which could give you an indication of how bad your salt problem is, ie the more salt tolerant the plant affected, the bigger the problem. The good news is that if your beans, carrots and onions etc are not showing any salt contamination symptoms, salinity is not a problem in your veggie garden.

Salinity Remediation

If salinity does turn out to be a problem for you, there are techniques which can be used to reduce the concentration of salt in affected soils. Working the soil to a depth of 50 to 100mm and then adding calcium (eg calcium sulphate also called gypsum) will displace the sodium in the soil profile, improving soil structure and reducing plant difficulties. This will take some time and it is really handy to have a soil conductivity meter to be able to keep track of how the process is going and the amount of gypsum required can be worked out from the soil conductivity. Well rotted manure can also be used as a substitute for gypsum if it is available.

2.4 Biological Aspects

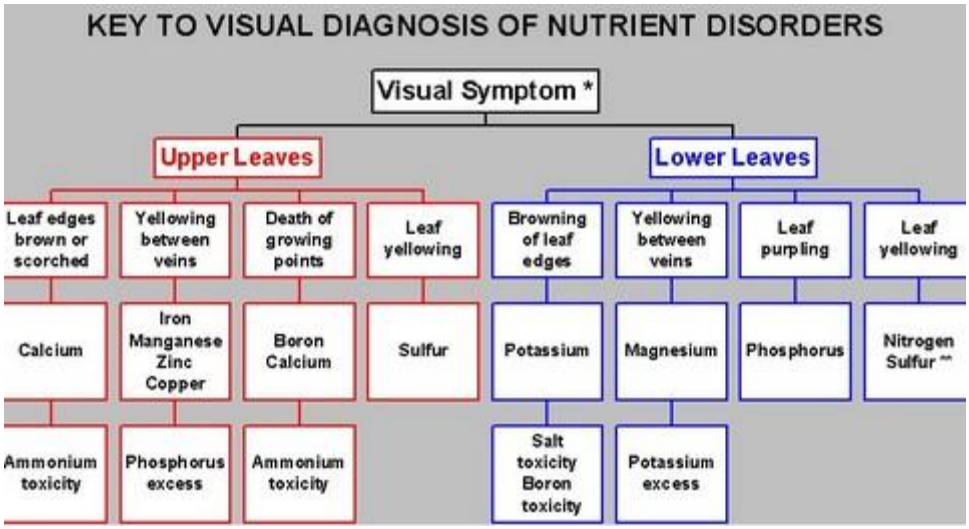
The soil supports a web of life or food chain commencing with the plants themselves, which start the whole thing off by using sunlight and chlorophyll to create simple sugars, made use of on a microbial level by bacteria, fungi and nematodes (microscopic worms). As you move up the chain, organisms become larger and more complex until you reach the climax predator(s) for the particular bioregion where you live. This is summarised by the illustration below.



But how does all this relate to testing the soil in the veggie patch in your backyard?

Using Plants to Detect Soil Nutrient Deficiency

Symptoms and signs of disease exhibited by the plants growing in your back yard may provide an indication of the deficiency of certain soil nutrients or their abundance to the point where they cause toxicity in the plants which are growing there. I have several books in my library which contain many hundreds of photographs illustrating how nutrient deficiency and toxicity symptoms manifest in individual fruit, vegetable, grain and pasture plants. On the surface, sorting through this mass of data and decoding what these symptoms mean to you in your situation could provide a daunting task. However the following diagram (developed by the University of Minnesota Extension Service and published **here**) provides a wonderful summary and flow chart making the job considerably easier.



* Symptoms refer to deficiency unless otherwise stated.

** Symptoms of sulphur deficiency usually occur on upper leaves first, but a general yellowing of the entire plant may occur under prolonged deficiency conditions.

Worm Numbers in Soil

The number of worms in a given amount of soil from you veggie patch or whatever may act as an index as to the health of your soil. The test is carried out as follows –

1. Ensure that the soil temperature is at least 10°C and has not recently been cultivated.
2. Using a trowel and spade dig out a 30cm cube of soil and place onto a tarp, garbage bag etc.
3. Gently sift the soil (if possible) through a garden sieve and then count the worms present in your sample.
4. Count up the number of worms discovered.

Ten worms per test confirms that your soil is in good shape where as 9 or less may point to problems such as lack of soil organic matter (in association with other tests) or the soil is too dry, there are pH problems, there may be pesticide contamination or the soil is too compacted.

In the event of a low worm count the idea to correct the situation is not to supply more worms but to fix the underlying problem – “if you build it they will come”.

Soil Respiration Test

One advantage of the above “worm” soil test is that you don’t need much in the way of equipment to carry it out, and what equipment you do need you are likely to have hanging around anyway. The soil respiration test, while it gives you a good handle on how the life in your soil is doing, does require some specialised equipment. I need to point out at this point that while I have read about this and have used Draeger tubes for a number of different analyses when I worked in the chemical industry, I have never actually carried out a soil respiration test.

The idea behind this test is that organisms in the soil take in oxygen and emit carbon dioxide in the same way that humans do and by measuring the amount of carbon dioxide emitted from a given volume of soil over a given time will act as an indicator of the biological health of the soil. The soil respiration rate can be affected by temperature, moisture, nutrient content and level of oxygen in the soil and so the result should be interpreted in combination with the results of other soil tests.

To carry out this test you need –

- 1 x 150mm diameter metal ring about 125mm long (eg 125mm cut from the end of a 150mm diameter tube)
- lid to fit the above with rubber stoppers
- Club hammer and wood block
- soil thermometer
- two sections of plastic tubing
- 2 needles
- Draeger tubes (to read CO2 – usually 10 tubes to a box) (Carbon Dioxide 0.5%/a; Mfr No CH31401)
- 140 cc syringe
- stopwatch or timer

The test needs to be carried out when the soil is close to Field Capacity, or in other words the area being tested has been watered well and then allowed to drain for 16 to 24 hours so that it is holding as much water as it can against gravity. Soil respiration will be inhibited if the soil is too dry or saturated with water. More detail on this test is available **here**.

To carry out the test –

1. Using the club hammer and wooden block, drive the ring into the test area to a depth of 75mm.
2. Place the lid on the ring and wait exactly 30 minutes.
3. Insert the soil thermometer into the soil 25mm from the ring and 25mm deep.
4. Assemble the Draeger Tube apparatus by connecting a needle to one section of tubing, breaking open both ends of the Draeger tube, connecting the Draeger tube to the other end of the needle tube, using the other piece of tubing to connect the syringe to the other end of the Draeger tube. (note: ensure the arrow on the side of the Draeger tube points AWAY from the needle.)
5. Insert the needle into the head space through the stopper, then insert the other needle into the other stopper just before sampling.
6. Take the sample by drawing back the plunger to the 100ml mark on the syringe over 15 seconds.
7. Record the soil temperature off the thermometer and read the concentration of CO2 off the Draeger tube by noting the highest point on the tube where the colour can easily be seen.
8.

To calculate the soil respiration in pounds of CO2-C per acre per day use the following equation –

Soil Respiration = PF x TF x (%CO2 – 0.035) x 22.91 x H where:

Pressure Factor (PF) = 1

Temperature Factor (TF) = (soil temperature in °C + 273) ÷ 273

(H) = Inside Height of the Ring in cm (2 cm)

3.0 Keeping the Place Fertile - Techniques

3.1 CROP ROTATION General

Crop rotation is the procedure of growing different crops successively on the same plot of land instead of growing the same crop on the same land year after year. This results in a number of benefits: -

A) As each crop takes or returns different nutrients to the soil it prevents or minimises the drain of nutrients on the soil so maintaining soil fertility. By crop rotation, mulching and adding compost regularly to the soil artificial fertilizers become unnecessary.
B) It prevents a build-up of pests and diseases which will attack a crop when it is grown year after year in the same ground.

A good plan for crop rotation is as follows: -

I. Root crops to start - eg potatoes, carrots, parsnips, turnips or onions . Root crops break up the soil and bring deeper soil nutrients to the surface.

FOLLOWED BY

II. A legume crop, eg beans (in summer) or peas (in winter). Legume crops fix their own nitrogen (an essential plant nutrient) from the air so when the root system decays the nitrogen remains for the next crop.

FOLLOWED BY

III. A leaf crop, eg lettuce, silver beet, spinach or cabbage . Leaf crops require a lot of nitrogen to produce a good yield of edible leaves so they make use of the nitrogen left behind by the legumes.

FOLLOWED BY

IV. Other crops such as capsicum, tomatoes, cucumber, broccoli or any others which do not fit into groups I. to III. above. Alternatively the fourth part of the rotation can be to leave the ground fallow to grow volunteer weeds which can then be dug under (BEFORE flowering and setting seed) to provide organic matter for the next crop .

THE ROTATION THEN STARTS AGAIN.

3.1.1 Crop Rotation in Our System

A couple of conversations recently have got me thinking about crop rotation and how it works in our system. Crop rotation is the practice of not growing plants from the same family, in the same ground, year after year and the reasons for doing it make a fair bit of sense –

- You don't get the same nutrients taken out by the same plants all the time so it helps to maintain soil fertility and
- There is less chance of getting a build up of pests and diseases of a particular crop because the soil gets a rest from it.

Some examples of crop rotation include -

1. A four course rotation – plant a "root" crop such as potatoes or carrots (to break up

the ground), followed by a "legume" crop such as beans or peas (to put nitrogen into the soil), followed by a leaf crop such as lettuce or silver beet (to make use of the nitrogen) followed by an "other" crop such as brassicas (cauliflower; broccoli) or solanum (tomato; capsicum) or even a fallow period.

2. A three course rotation I have heard of that has been used in the UK is potatoes, followed by brassicas, followed by and "other" crop ie everything else.

3. Rotate by family – This simply means that you don't sow plants from the same family in the same bed one after the other. The plant families are as follows

a. Alliums – onions, garlic, leeks, shallots, spring onions, chives
b. Beets (also referred to a chenopodiaceae) – beetroot, silver beet, spinach
c. Brassicas (also referred to as crucifers) – Brussels sprouts, cabbage, kohlrabi, cauliflower, broccoli, kale, radishes, turnips.
d. Compositae – salsify, endive, lettuce, globe artichoke
e. Cucurbits – cucumbers, melons, gourds, squash, pumpkins
f. Grains – sweet corn, dent corn, wheat, rye
g. Legumes – peas (dwarf and runner), beans (dwarf and runner), broad beans
h. Solanum – potatoes, tomatoes, egg plant, capsicum, chillies
i. Umbellifers – parsnip, parsley, carrots, celery, dill, fennel, coriander

The whole idea makes sense to me, until I tried and apply it in a back yard situation. If you are growing a whole load of cabbages, it makes sense not to follow the cabbage crop with a broccoli crop in the same ground. However, If you are in a backyard situation and following other organic principles like interplanting your crops (ie mixing them up in the same bed), it makes things much more difficult, unless you want to keep up with unrealistic levels of note taking!

To me the idea of crop rotation is designed for large scale growers and in the back yard it becomes almost irrelevant. Even so great an authority as the Yates Garden Guide has this to say about crop rotation –

“In Australia, there is a natural rotation between warm and cool season crops. Providing you apply organic matter and are aware of the possibility of related crops contracting a disease from a previous crop, you need not be concerned about crop rotation”

Even having just demolished the idea, I have found that I do want some form of crop rotation in our backyard food production process. This is because the way we produce our food is that the beds, year-round, will have some lettuce and some brassicas in them. In summer they will be interplanted with beans, other salad crops, etc and in winter they will be interplanted with spinach, peas etc, but that central theme will always be brassicas and lettuce. Again, this is because things like broccoli and cabbage will grow year-round and they are also what we eat.

There are some crops which we tend to plant once as a whole bed and then harvest

them over the greater part of a year such as carrots. There are other crops which have a longer bearing period than the 5 to 6 months allowed in our rotation between chooks or are slow growers and take a while to come to harvestable size. And example of the former is silver beet, and an example of the latter is celery. If we interplant these crops as we would normally, we are just starting to get a crop or they are well in stride when it is time for the chooks top come through and raze the place (as they do so well).

There are other crops which we plant once a bed at a time and then harvest all together, like our onion crop. Onions all get sown into boxes at the same time in April then planted out into a bed in spring, at the same time. And then we harvest them to store, all at the same time, and they keep well enough so that they are still ok by the time we get to the end. In practice we grow about 5-6 months worth of onions.

Likewise, corn. You have to plant corn in a block to get it to pollinate so we usually grow

a bed or two of corn each summer, then harvest it over a fairly short time (a week or two generally) and have corn parties! During the harvest time it is “corn with everything” for that couple of weeks.

Then there are the carrots! We plant a bed’s worth of carrots in late winter or early spring and that one bed is usually enough to see us through for the rest of the year. We eat the largest first and then the remainder grow into the space left, so that by the time they are starting to run up to seed in the following spring, the new carrot bed is just taking off (although sometimes we have problems and not enough come up like happened last year). The carrot bed gets a full year rest from brassicas and lettuce!

Up until now, which beds get the full plant out and which get the standard interplanting “lettuce and brassicas plus” line-up has pretty much depended on which bed was free when I wanted to do the planting. To help me remember which beds, have had what

planted into them, when, I have developed a (you guessed it!) Excel spreadsheet. This will help me to keep track of when each bed had its last had its full bed cleaning crop. In that way I will be able to manage things better and ensure that every bed gets a relief from our standard crops at least once a year.

The system that we have in place now has worked well so far, but a bit of crop rotation can't hurt!

3.2 MULCHING – General

Mulching is the practice of forming an organic layer on top of the soil around the plants, even over the entire vegie patch. This organic layer has a number of effects on the soil and plants in the surrounding area:

1. It keeps the soil surface cool in summer allowing micro-organisms to function at the soil surface and continue to breakdown organic matter and release nutrients.

2. It conserves moisture - A very important point in times when water may be in very limited supply. A mulch as well as reducing evaporation from the soil surface also increases the proportion of the soil water present in the plant root zone, where it counts.

3. Weeds are suppressed - This reduces or eliminates the need for cultivation or worse yet, pulling out the little fellows by hand. This is an important point because weeds will compete with your crop for light, nutrients, water and space and in so doing can seriously reduce crop yields.

4. Nutrients are released by the breakdown of the mulch so that the vegies have a built in, time release food source. The organic matter when incorporated into the soil will also improve soil structure and therefore fertility.

5. The surface of the soil under the mulch is not compacted by rain drops so water runoff is reduced and infiltration of rain correspondingly increases. By the same token if rainfall is high and drainage not what it should be, mulching can contribute to waterlogging of the soil so keep an eye out for this.

Some materials used for mulching -

a) Compost - Ideal .
b) Hay or straw - Ideal .
c) Grass Clippings - Can tend to form a water impermeable layer so they should be mixed with sawdust of compost prior to use .
d) Dry leaves - Can also form an impermeable layer so should be shredded or mixed with other material prior to use .
e) Sawdust and wood shavings - Radiata pine material is not suitable as a mulch .
f) Animal manures - should be old and well-rotted down before use or they can burn the plants .

3.2.1 Mulching in our System

Mulch is a material that may be organic (compost, hay, straw) or inorganic (rocks, gravel) that is applied to cover bare soil. It has a number of advantages over leaving the soil bare –

- It reduces evaporation, keeping the soil moister and reducing the need for watering.
- It insulates the soil against extremes of temperature.
- If it is organic, it will break down and provide nutrients for plants.
- It can help support bacterial or fungal soil biota (more on this later).
- Weed growth and the germination of weed seeds is suppressed.
- Rain drops hitting bare soil can result in the soil surface being compressed causing the rain to then run off. Mulch absorbs the energy of the falling raindrops allowing water to infiltrate the soil rather than be lost.
- Soil erosion is reduced, due to reduced rain runoff.

So you can see that there are lots of good reasons to use mulch when you are growing your fruit and veg, herbs, flowers etc. For these reasons I integrated mulch into our

growing regime very early on. We use two main types of mulch, straw and wood chips with the occasional application of other stuff.

Straw Mulch

Straw is an organic mulch that supports bacterial soil biota which favours the production from our annual vegetable beds. Over the years that we have been growing, depending on availability, we use straw, but we have also used Lucerne hay when we wanted to add a nitrogen boost to the soil. Also, for a couple of years, there was a local producer of grass hay which we used extensively for as long as we could, but they went out of business years ago. We now buy wheaten straw from a local produce merchant only a couple of kilometres away.

Bed mulched and ready to plant out

Wheat straw is great stuff for mulch, but one downside is that it will contain variable amounts of wheat seeds. This is great if you want to grow a bit of wheat in your mulch, but not so much fun if you don't. We have strategy for this, before going onto the veggie patch, each bale of wheat straw goes through the 'Retirement Village'.
The retirement village is a shed where we keep our chooks that are a bit old for the chook tractor and not as productive and as I need I toss in a bale of straw for them to sort through. This has a number of advantages –

- They remove and eat the wheat seeds,
- They break the straw down a bit so it is easier to handle, and
- The add manure to it, increasing the fertility added to the soil and adding nitrogen to the high carbon straw to facilitate it breaking down.

The retirement village, where chooks root out and eat wheat grains and tell each other stories of what it was like "back in their day"

Once the chook tractor has dug over and manured a patch, the straw from the retirement village is applied roughly at the rate of one wheelbarrow full per metre squared. In most cases this is enough, but occasionally we might get a bit of a problem weed infestation (like oxalis) and I will get hold of some newspapers, soak them, then apply them in pack of 10 to 20 sheets, overlapping over the full bed, before applying the broken down straw.

Bed with soaked newspaper applied and partially covered with straw

The mulch usually holds up for the six months that the bed is producing then the chook tractor comes back round and the chooks then dig in any remaining straw into the bed, and the process starts again.

This cycle has been ongoing for over 15 years and we find it works very well.

Wood Chips

Under the mulberry tree, freshly applied wood chips

Wood chips support a fungal soil biota which allows trees, shrubs and other perennials to do well. For the most part we buy it in every few years as it is needed, and put it under the mulberry tree, around the **fruit tree circle**, along the front of the property on the **LUFFA**, and various other perennial beds.

Pile of woodchip ready to be applied

A while ago, while driving around I noticed a pile of wood chips on some vacant land near a roundabout. It appeared to me that an arborist was using it as a dumping ground for tree shreddings rather than taking them to the tip, thus saving a bit of money. This worked pretty well for me as it was not far from home and I could go over, fill the back of the car up and then come home and spread it. Unfortunately someone (I suspect the land owner) put a stop to it by cleaning the land up and then installing a fence. So we are back to buying it again.

If you have a decent amount of land, you can approach local arborists and let them know you would like to receive a load of shreddings they will often deliver them for free. The will, however deliver what they have in the truck and it will be all or nothing, and the 'all' may be 25 to 30 tonnes. This doesn't work for us because we just don't have the room but may work for someone with land to spare, and/or lots of friends

who could share in your bounty. Otherwise, keep an eye out on vacant land in your area for some piles of unwanted wood chips!

Front garden, re-mulched

Other Stuff

We do make some use of organic material that is produced on our place –

Corn Stalks – If we get a good season for corn, I will pull up the stalks and run them through our old electric shredder. Like me, it has some quirks and can be a pain at times, but eventually I got it to shred up the cornstalks from two patches, effectively providing free mulch for about half of one of the three metre beds.

Cornstalk mulch

Some old bugger shredding cornstalks in my back yard!

Banana leaves and papyrus – The Jerusalem artichoke bed gets a mulch that is a combination of dried out banana leaves and papyrus from the water garden. The

banana circle in the back yard is prolific in shedding banana leaves all over the place so we gather these up and put them of the Jerusalem artichokes, and at the same time, we gather papyrus stalks that have dried off and place them over the top of the Jerusalem artichokes as well, forming a mulch that is light but which also has good coverage.

Papyrus and banana mulch on the Jerusalem Artichoke bed

Irrigation

We do get some extreme weather out here and it can get very hot and dry in summer, we have found that applying mulch where we can keeps the soil and the plants happier, and means we don't have to irrigate as much. We have systems that allow us to irrigate through the mulch directly into the soil underneath, **ollas** for the veggie beds and **deep pipe waterers** for the perennials. This allows us make the best use of water in dry times.

Ollas

Deep Pipe Waterer

Downside

We have found lots of up-sides to mulch and not so much downsides, but one that we have found is that lots of rain, particularly in the colder parts of the year, can result in soil waterlogging. Plants like citrus trees that do not cope well with wet feet can be damaged. If this happens, we scrape the mulch away from the base of the plant until things dry out.

3.3 Green Manuring – general

This is the process of growing a crop on your vegie patch and then digging it in to provide organic matter. This is a good idea when you are opening up a new area or as part of a crop rotation. The most value is obtained by using a legume eg peas, beans, clover, or lucerne which fixes nitrogen at the same time, releasing it to the plants as it breaks down. At least two weeks should be allowed between turning in the green manure and planting vegies to allow the green manure some time to break down. The green manure should also be turned in before it flowers so it is at a succulent stage of growth and will break down earlier and no seed is set to come up as a "weed" later.

3.3.1 Green Manuring – what I did

I don't use green manure that much to keep by beds fertile, not because it is a bad idea but because there is no prolonged fallow period in my rotation where it would be practical to fit it in. Green manure is a great idea though and a good organic way to maintain fertility. The idea is to sow a mixture of legumes and annual grains and vegetables, let them grow up but before they flower cut them down and either dig them in or leave them on the surface to rot down.

The benefits of including a green manure in your backyard veggie rotation include –

- Deep minerals can be brought to the surface, for use by later crops.
- Increased levels of nitrogen (from legumes) and carbon (from the grains and vegetables) in the soil.
- Increased soil organic matter.
- Break disease cycles by totally changing crops grown.
- The soil is loosened enabling air, roots and water easier and deeper penetration.
- Keeps the soil covered when nothing else is being grown, keeping the soil temperature down and supporting soil life.

To get the best out of your green manure crop it needs to be grown quickly and well, so don't sow it into dry sand and expect it to fix everything. There needs to be residual fertility in the soil for the green manure to capitalise on and it needs to be watered regularly to ensure the lush growth that will allow you to get the most out of it.

Choose the species which will make up your green manure so that they will grow well in your area and grow well at the time of year you want your green manure to grow. There are a wide variety of plants which can be used as green manure, so choose a mix of species and each will contribute their particular goodies to the soil.

Choosing your Species

As mentioned above a mix of species is desirable with some nitrogen fixers and some other species mixed in, appropriate to the time of year you want to plant your green manure. Below is a list of species to help your design your mix –

Autumn/Winter – nitrogen fixers (Legumes)
Broad Beans, Dun pea, Fenugreek, Lucerne, Lupins, Peas, Red Clover, Subterranean Clover, White Clover, Vetch.

Autumn/Winter – grains & vegetables
Barley, beet, buckwheat, corn salad, dill, endive, Japanese millet, kale, linseed, oats, purslane, radish, rapeseed (Canola), rocket, rye, spinach, turnip, wheat, white mustard.

Spring/Summer – Nitrogen Fixers (Legumes)
Broad beans, cowpea, fenugreek, medic, mung beans, soybeans, vetch

Spring/Summer – grains & vegetables
Basil, beet, buckwheat, coriander, dill, endive, Japanese millet, mustard, purslane, radish, rocket, turnip, wheat, white millet.

What I did

As previously mentioned, I don't use green manure much but one of my wicking beds came free after a good crop of potatoes. Potatoes are gross feeders and I need to replenish the soil but on top of that the "organic mix" I had filled the wicking bed with was somewhat less satisfactory than I had hoped. While it was free draining it did seem to be lacking in nitrogen and perversely enough, organic matter. It dried out quickly, wicking bed or no wicking bed. A quick top dress with chook poo produced a good potato crop but now was the time to correct the problem properly.

I went through and removed any residual tiny spuds (I'm sure I missed a few) then threw on a couple of bags of mushroom compost and worked them through the top 100mm – 150mm of the bed with a small hand hoe. Once I was happy with that, I broadcast sowed the green manure mix, usual seeding rate is 10gms - 20gms per square metre but I wanted a thick coverage so I put on somewhat more than that. With the seed sown I top dressed the bed with a thin layer of compost and then watered the living daylights out of it to ensure germination.

Germination rates were good and before long I had a healthy, lush growth of green stuff covering the top of the bed. I left it grow for several months and just as the oats were preparing to flower I cut the plants back to almost ground level with a pair of hand shears, leaving the cut material on the ground as mulch. You can do this several times to increase the level of organic matter but I only wanted to do it once before replanting, so after a few days I wound up uprooting the plant material still in the ground to prevent it from re-growing. On a large scale it would be ploughed or rotary hoed in.

The result has been more fertile soil and, as a result, happier plants.

3.4 Companion Planting

I have always wondered about companion planting. I have tried it over the years, sometimes it worked and sometimes it didn't. Years ago we had a peach tree with leaf curl, so I planted garlic around the base of the tree and the next season the leaf curl was gone. I variably plant basil and tomatoes together sometimes and separately sometimes but have not noticed any difference between the two planting regimes. With some of the books which have been written and innumerable internet companion planting charts it seems to be: plant this this this = good; plant this with that = bad. This sort of approach seems to me to have some problems attached to it.

The Problems

1. The information is quite often imported from overseas, particularly from the Northern hemisphere and even if it works over there, there is no guarantee that the advice, when transplanted into new continent, climate and ecosystems, will still be effective.

2. The information may be anecdotal in nature, with no confirmation by scientific trials. The assumption tends to be – "it worked here for me…..it will work for anybody!"

3. There is variable agreement between systems and sources of information. A quick review of some internet charts will show discrepancies. For example on one chart I saw, beans and beets are good companions, but on another chart they were bad companions. Both charts can't be right.

4. Lack of information – Even if the "plant this with this" were to work there seems to be an enormous lack of information on how this pairing should be used to advantage. Why should they be paired together, who benefits and what do they get? Is a certain pest or disease deterred? Is there an improvement in flavour? How much of each one

relative to the other needs to be grown to get the effect? Or is the answer some nebulous “they grow better together”?

In general terms, while it is possible to accept the claims of some of these systems on faith, I would rather see some sort of research to back up the claims. Companion planting is not all “woo” however, there are some plants which have a demonstrated beneficial effect on those around them, and to a lesser extent some have a negative impact.

Good Companions

Good companions are good companions because they exhibit one or more of the following beneficial effects, they –

1. Disguise plants from pests
2. Encourage pest eating predators
3. Choke out weeds
4. Improve fertility
5. Act as trap crops

1. Disguising plants from pests

This effect usually works in one of two ways – the companion plant makes the target plant look different, or smell different.

Look Different

Think “camouflage”, the idea is to break up the outline of the target plant so that the pest does not recognise it as it scans for food or a place to lay eggs. This can be achieved by interplanting the target with taller crops to break up the outline, rather than a discrete line or block of the target crop. It may also require planting different confuser crops around the target one.

Example: when planting cabbages (subject to cabbage moth and cabbage white butterfly) interplant with celery and silver beet which will grow higher than the cabbage and break up its outline.

Smell Different

Many pests pick out their mark by smell so that by interplanting your vegetable plots with herbs and other aromatic plants or using them as a border, the pest will be confused by the strong odours of the aromatic plants. Again, you may need to plant lots of confuser aromatic plants around a smaller amount of crop. These strongly smelling crops can actually repel pests as well as confusing them.

Examples – basil, chamomile, coriander, curry bush, dill, fennel, garlic, horehound, yarrow

2. Encourage pest eating predators

There are two kinds of predators to consider here – insects and birds.

Plants which attract beneficial insects to predate the pest insects in your garden generally provide nectar which appeals predators. They will then either consume the insects as well, or lay their eggs in the pests and allow their larvae to consume them. Although it sounds disgusting, it is the way things work.

Examples: alyssum, calendula, heartsease, Queen Anne's lace and zinnias

It is good to plant spring flowering natives to attract the types of birds which will help control the pests. The pests start breeding up at a lower temperature than the predators do and with the right natives in place the birds will be attracted and keep the pests in check until the predators have a chance to catch up.

Examples: grevillea, banksia, melaleuca and correas (research which varieties of these natives are spring flowering in your area).

3. Choke out weeds

To get the most out of these plants you need to plant them thickly along the edge you want to defend, eg the edge where the lawn meets the veggie patch or the fruit tree drip line. The edge needs to be planted with the weed chokers in rows three to five plants deep, but some may not be a permanent solution if the issue you are wrestling with is kikuyu grass.

Examples are – comfrey, garlic chives and lemon grass

4. Improving fertility

There are three effects to take into account here – nitrogen fixers, dynamic accumulators and green manures.

Nitrogen fixers (legumes) have a symbiotic relationship with bacteria in nodules on their roots which turn atmospheric gaseous nitrogen into soluble nitrates which plants

can use. By growing legumes in the rotation their roots will release the soluble nitrogen after they die or by cutting back the foliage above ground there will be a corresponding die back of the roots. This will result in nitrogen becoming available for surrounding plants.

Examples: peas, beans, clover, vetch and lupins.

Dynamic accumulators are plants which put down a deep taproot allowing them to harvest nutrients below the root zone of the usual crops. To make use of these extra nutrients the leaves of the dynamic accumulator are pruned back and then left on the soil around the plants to be fertilised so that the leaves form a mulch, then break down to release these stored nutrients. Another way is to harvest the leaves and then compost them, before feeding to the plants.

Examples: dandelion, comfrey, stinging nettle and dock

Green manures are grown around plants to form a groundcover, then slashed down before they flower so that the plants will break down and release their nutrients for use

by the current or future crops. Green manures are generally a mix of nitrogen fixers and other leafy plants appropriate to the time of year they are to be planted.

Examples: buckwheat, linseed, mustard, oats.

5. Act a trap crops

Trap crops are planted in and around the target crop to attract pests to them and away from the target crop. Of course, it is possible that it might backfire and attract pests to your crop if that is your only pest control method operating so it needs to be carefully managed. When pests do cluster around the trap crop, this concentration of pests is highly likely to attract insect or bird predators in the area. Alternatively, you could remove the trap plants, complete with bugs, for destruction elsewhere.
The use of trap crops is the most research-intensive method of companion planting because the trap crop will be very specific, depending on your target crop and the pest you wish to deal with. So you will need to make sure what pest you ae trying to deal with before setting out to use this method.

In addition, trap crops can be used in association with highly aromatic plants used to disguise the target crop. Quite often these aromatic plants will act to repel pests and by having the appropriate trap crop in the area the pests will be repelled from the target crop but steered toward the trap crop. This is the so-called push-pull pest control strategy.

Examples: Chinese cabbage or mustard, allowed to go to seed to attract aphids, nasturtiums to attract whitefly.

Bad Companions

These are plants which will work to prevent your target crops from flourishing and so should be isolated from the main crop area, or put actions in place to deal with them. They are bad companions because –

1. They will compete with your target crop for resources (water, nutrients, light), or
2. They produce and release into the air and/or soil chemicals which retard the growth of competing plants (ie your target crop) or reduce seed germination in the area, called allelopathy.

or both.

1. Competition

There are a number of ways where this may become an issue. Any large tree will be a bad companion for growing edible crops, vegetables in particular. At the very least they may shade the area where you want to grow your veggies, this will reduce the varieties you might want to grow to ones which are shade tolerant. Large trees also have extensive root systems and even if they are in a neighbour's yard they can send roots

out beyond the tree drip line to harvest all that water and fertility you work so hard to provide for your veggie patch. Some large trees, especially eucalyptus may also demonstrate an allelopathic effect on surrounding vegetation.

Vegetables are also classified as light, medium or heavy feeders, so if you plant a whole stack of different veggies together which are also heavy feeders, they will compete with each other for resources which in the end will result in reduced yields. It is better to interplant the heavy feeders with lighter feeding plants or else put more work into preparation of the beds before planting so that there is enough fertility for all. Interplanting with nitrogen fixers is one way of reducing problem due to this type of competition.

Examples of heavy feeders: corn, tomatoes and zucchinis.

2. Allelopathy

As mentioned above plants which exhibit allelopathy get and unfair advantage competing with other plants by releasing chemicals into the soil and air which retard

the growth of other species, reduce germination of seeds or both. Sometimes the effect is even more pronounced when the plant dies and is decomposing such as rye (the grain) or marigolds. This can be put to use by harvesting and laying down these plants as cover in areas where plants are not wanted such as pathways.

The poster child for allelopathy is the black walnut, due to the production of a compound called juglone which is washed down from the leaves onto the surrounding earth, killing or stunting the growth of plants in the area. The black walnut is not alone, however and common vegetables such as corn show allelopathic effects when young and fennel and even broccoli and cabbage show allelopathy towards a wide variety of other vegetables.

A list of plants useful in the various aspects of companion planting is provided as Appendix 2

4.0 Keeping the Place Fertile – Adding Nutrients

4.1 Adding Nutrients

Just like animals (including us) plants need the right sort of nutrients in the right amounts to be happy healthy and productive and when we remove crops from the soil and consume them, the nutrients must be replaced. Originally this was done with naturally occurring materials such as manures, ash and compost but with the invention of inorganic fertilisers (originally called artificial manure) we went away from naturally occurring materials and, as usual, stuffed things up. The inorganic nutrients don't take into account the importance of soil micro-life and as the yields reduce more fertiliser is needed to keep pace. They also tend to be very soluble being easily leached into our waterways and ground water causing pollution and some are oil based and come with all the problems that entails.

However, the wheel is turning and organic farming and gardening is making a very strong comeback and you can be part of that comeback in your own backyard veggie patch.

The theory at the start may be a bit heavy but it will give you a good basis on which to make decisions on how to use the materials available to you to keep your little patch of heaven producing the food you love.

A little Bit of Chemistry

While it does not tell the whole story, a measure of the usefulness and effects that a fertiliser will have, for both chemical and organic fertiliser is the NPK ratio. The NPK ratio gives an indication of how much of the three major nutrients a given fertility increasing material contains, but perhaps I am getting ahead of myself because we need to talk a little bit about the chemical elements that a plant needs and these are generally divided up into three major nutrients, three secondary nutrients and six minor or trace nutrients. What follows is a summary of what each nutrient does, what the

effects are when the plant is suffering from a deficiency of that nutrient what you can add to the soil to bring the nutrient level back to scratch.

The Major Nutrients

The major nutrients are nitrogen (chemical symbol "N"); phosphorous (chemical Symbol P) and potassium (chemical symbol K) hence the three together are referred to as NPK.

Nitrogen (N) – is important for leaf growth – deficiency results in pale or yellowing leaves - The best way of correcting a nitrogen deficiency in an existing crop is to add a well rotted high nitrogen manure such as chook or pigeon or to dilute human urine 1:10 with water and apply with a watering can.

Phosphorous (P) – is important for healthy plant growth, the formation of flowers and setting of fruit and seeds – deficiency results in poor root growth and stunted and sometimes purplish leaves – To correct this deficiency add bone meal if you can get it or blood and bone or apply human urine as above.

Potassium(K) - is important for strong support cells in plants and to ensure plants are healthy and resistant to disease – deficiency causes weak stems with limp yellowish leaves that may have scorched looking edges. Fruit set will also be reduced on fruiting plants – to correct potassium deficiency wood ash is the best additive or seaweed as mulch or made into a tea as set out under Trace Nutrients.

The Secondary Nutrients

These are the "tweens", being required in relatively larger quantities than the trace nutrients but not so much as the major nutrients.

Calcium (Ca) –is important for strong cell walls and growing tissue like root tips – deficiency results in new growth being stunted and distorted and growing tips curling/dying, can cause blossom end rot in tomatoes – Correcting calcium deficiency is

usually done with agricultural lime although dolomite or gypsum (both made of ground rock) will not affect pH but still add calcium. Ground eggshells or sea shells can be used if you can get enough and blood and bone will also contribute calcium as will most manures.

Magnesium (Mg) – is important in photosynthesis for the plant – deficiency causes leaves to get yellow stripes, the older leaves being affected first – to correct a magnesium deficiency the classic thing is to dissolve 1 tablespoon of Epsom salts (magnesium sulphate) in 4 litres of water and apply with a watering can but dolomite (a mixture of calcium and magnesium carbonates) will also work.

Sulphur (S) – sulphur is a component of plant proteins and is associated with the formation of chlorophyll – Deficiency results in the older leaves going pale, followed by the whole plant. To correct a sulphur deficiency adding composted brassica leaves (cabbage, cauliflower, broccoli etc) or garlic to the soil will help. The classic fix was to apply a dusting of elemental sulphur or Epsom salts.

The Minor or Trace Nutrients – also referred to as "trace elements".

While these nutrients are required in very small quantities, some can be toxic to plants when present in excess, they also make their presence felt when they are lacking, sometimes presenting strange symptoms as a clue to the deficiency disease you may be dealing with.

Boron(B) – is important for growing tissue in young plants – deficiency results in stunting of growth with yellowing stripes on the leaves and pale green tips of leaves, it can also result in breakdown of internal tissues in vegetables such as celery stems and broccoli flower buds.

Copper(Cu) – Is an enzyme activator and important in photosynthesis – deficiency results in "burning" of the leaf margins and yellowing with resetting or multiple bud formation in flowering plants. It may cause dieback in citrus and some other fruit trees.

Iron(Fe) – is also important for formation of chlorophyll in plants and is an enzyme co-factor – deficiency results in yellowing between the veins of young leaves but no initial stunting of growth, later older leaves become affected and growth becomes stunted.

Manganese(Mn) – is similar to iron – deficiency results in yellowing similar to iron leading to a striped or spotted appearance of the leaves.

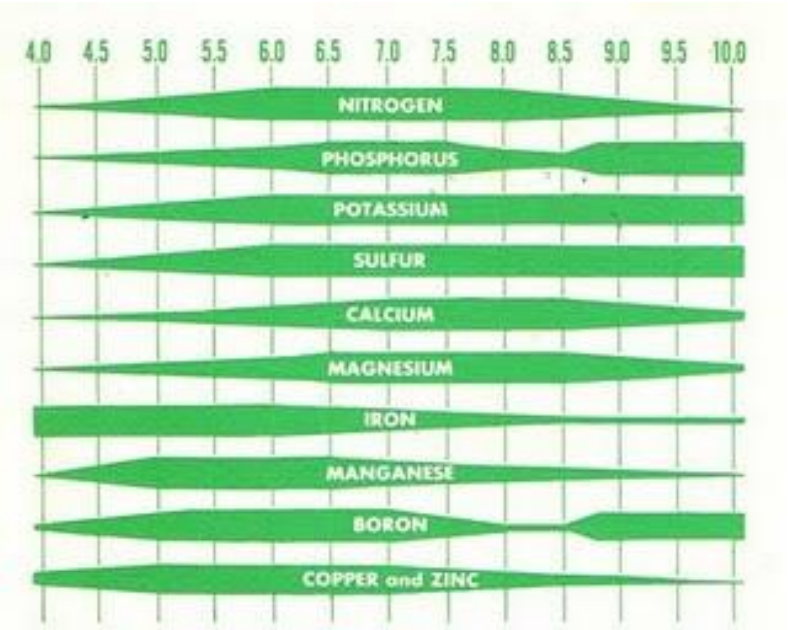
Molybdenum(Mo) – is important to allow the plant to convert nitrogen into plant proteins – deficiency shows similar symptoms to nitrogen deficiency leaves turning pale green then stunting of the whole plant and leaves bleaching and withering.

Zinc(Zn) – is an enzyme activator similar to copper – deficiency results in growth stunting and the formation of “little leaf”.

The easiest way to provide trace elements for the veggie patch is to add wood ash, compost, well rotted sawdust, horse manure or seaweed tea made by washing the salt of seaweed in fresh water then steeping in fresh water for three to four weeks and dilute to the colour of weak tea and add with watering can or spray onto affected plants.

What about pH?

The soil acidity or alkalinity, generally referred to as soil pH and covered in detail in other articles, also has an impact on the nutrition of your backyard veggies because if the pH is wrong, some nutrients may be bound up and unavailable to your plant while others may be available to the point of toxicity. The graph below has been around forever and is reproduced by everyone and it gives an excellent representation of the availability of nutrients as the pH varies. The wider the line the more available the nutrient, of course the message to take away from all this is if your pH is between 6.5 and 7 you have nothing to worry about, but as you move away from this ideal range the availability reduces in most nutrients to a greater or lesser degree.



Availability of nutrients (ph range). Bar represents degree of availability.

NPK of Materials available in or close to urban/suburban areas

So now you hopefully understand a bit more about what nutrients plants need to be healthy and productive, here is a list of commonly available organic materials that can be added to the soil to increase fertility and what the NPK levels are for each.
These figures are rough and will vary from batch to batch

Material	N	P	K
Beans, Garden (seed & hull)	0.25	0.08	0.3
Blood & Bone	3.6	8	10-20
Cattle manure (fresh)	0.29	0.25	0.1
Chicken Manure (fresh)	1.6	1.0-1.5	0.6-1.0
Clover	2.0	0	0
Coffee Grounds	2.0	0.36	0.67
Corn cobs	0	0	2.0
Cornstalks	0.75	0	0.8
Compost	0.5	0.27	0.81
Couch Grass (green)	0.66	0.19	0.71
Cucumber skins (ash)	0	11.28	27.2
Eggs	2.25	0.4	0.15
Eggshells	1.19	0.38	0.14
Feathers	15.3	0	0
Grapefruit Skins (ash)	0	3.6	30.6
Grass clippings	1-2	0-0.5	1-2
Hair	14-15	0	0
Horse Manure (fresh)	0.44	0.35	0.3
Human Urine	15-19	3-5.4	1-2.5
Lemon Skins (ash)	0	6.33	1.0
Lucerne hay	2.45	0.05	2.1
Milk	0.5	0.3	0.18
Mud (fresh water)	1.37	0.26	0.22
Oat straw	0	0	1.5
Orange Skins	0	3.0	27.0
Peanut shells	3.6	0.15	0.5
Pea Pods (ash)	0	3.0	9.0
Pea (vines)	0.25	0	0.7
Pigeon manure (fresh)	4.19	2.24	1.41
Pine Needles	0.5	0.12	0.03
Potato Skins (ash)	0	5.18	27.5
Potato haulms (dried)	0.6	0.16	1.6
Rabbit manure	2.4	1.4	0.6
Seaweed (dried)	1.1-1.5	0.75	4.9
Sheep & Goat Manure (fresh)	0.55	0.6	0.3
Sorghum Straw	0	0	1.0
String Beans (strings & stems, ash)	0	4.99	18
Tea leaves (used)	4.15	0.62	0.4
Tomato leaves & stems	0.35	0.1	0.4
Wheat bran	2.4	2.9	1.6
Wheat Straw	0.5	0.15	0.8
White clover (green)	0.5	0.2	0.3
Wood ash	0	1.0-2.0	6.0-10.0
Worm castings	1.0	1.0	1.0

Home Produced Soil Additives

Compost – is a good all-purpose fertility improver and by composting leftover food waste some of the nutrients removed in harvesting can be returned to the soil. More details on composting and making a bokashi bucket are covered in detail later in this eBook.

Wood ash – if you have a wood burning stove or have friends with one, rather than throwing out the ash, add a light dusting next time you are preparing a veggie bed for planting. It is alkaline and so may raise the pH of your soil but a small amount added to healthy organic soil is unlikely to have a huge effect. Wood ash is great for adding potassium to your soil.

Seaweed/kelp – seaweed is a great addition to the veggie patch if you can get hold of it, gather it and bring home a bag full next time you take the kids to the beach. As well as contributing major nutrients it is a good source of the trace nutrients as well, but make sure you wash the salt off before you use it. You can dry it out, crumble it up and add it to the bed before planting, add it to an existing bed as a mulch or steep it in a bucket of water for three to four weeks and apply with a watering can as a general tonic.

Worm castings – In an urban/suburban area you are most likely going to be producing this in **smaller amounts**, but it is very rich in beneficial soil bacteria as well as chemical nutrients. You can use it to make seed raising mixture, spread it around growing plants under the mulch or add it into the hole before planting your veggies to give the plant a boost when the roots find it.

Poultry manure – Even in the city most people can find room for a few chooks and while their manure is a bit rich to add fresh to growing plants it will give the soil a boost if added when preparing the bed or composted first. Rather than haul the stuff around, we use a chook tractor which means that the chooks apply it direct to the bed, and then when the bed is watered and mulched before planting, it attracts worms into the bed. If

you have to buy it in, check that it has not been sprayed with insecticide to keep the flies down.

Urine- There is talk about "peak phosphorus" because we currently get our phosphate fertiliser supplies from deposits of ancient guano which are then mined, and is starting to run out. The answer is to recycle nutrients by diluting our pee ten to one with water and applying to the veggie bed. Contrary to popular belief urine is not sterile so if you are not well, particularly due to bladder infection, don't use it. I wouldn't broadcast about this fertilising practice too much either, the neighbours might not understand your good intentions. This is also covered in more detail later in this eBook.

Liquid manure – In general terms liquid manure is made by steeping a nutrient rich material in water for a time to extract the nutrients and then diluting the resultant "tea" until it looks like weak tea and then applying directly to the plants. The nutrient rich material can be seaweed as mentioned above, manure or better yet a mix of manures, comfrey or nettle leaves or even just a mixture of weeds steeped in water.

Bought In Soil additives

Blood and bone – This is a great way to add phosphorous and potassium to your veggie patch although if you are vegetarian or vegan you may have some ethical problems using it. You should keep it in a sealed container away from pets; years ago my father's dog broke into his garden shed and ate his entire blood and bone supply. It didn't hurt the dog but sure crapped off my father.

Rock dust – Rock dust adds trace nutrients to the soil in an insoluble form that is only accessible slowly as the dusts is broken down by the enzymes released by soil microorganisms. Rock dust also is good for and attracts worms to your soil. You might not see it in your local nursery or hardware store but it is available from supplies on the net such as remin.com.au who are on the south coast of NSW.

Horse/Cow manures – If you don't know what the worming history of the horse is it is better to compost horse manure before applying it to the veggie bed but well-rotted or composted horse or cow manure is a great way to add organic matter to your soil.

Dolomite & gypsum – These materials are ground rock containing calcium and, in the case of dolomite, magnesium as well. If you struggle with clay soils as we do around here adding a calcium containing material will improve soil structure. The clay is sodium clay and has very fine pores, adding the calcium material allowing it to react with the clay replaces the sodium with calcium and calcium clays have a much more open structure, so the soil becomes much more free draining. Gypsum is often sold as "clay breaker".

Maintaining soil fertility is basic to producing our own veggies, and keeping our plants happy and healthy so that they have the same effect on us when we eat them. By returning nutrients to the soil using organic production principles you will make sure that your veggie production is maintained in a sustainable manner.

4.2 Urine as Fertiliser

While urine may be considered (to use the scientific term) 'icky', it may also be considered a valuable resource. It is a high nitrogen fertiliser and also contains other plant nutrients such as phosphorus, potassium, sulphur, calcium and magnesium as well as sodium and chloride and other micronutrients in varying amounts depending on the donors' diet. The amount produced per day will vary depending on how much water the donor drinks but it usually somewhere between 0.8 to 1.5 litres per day for an adult. Over a year the urine of one adult can provide 2kg to 4kg of nitrogen.

I found the above information while trawling through the net on various sites as well as reading through some scientific reports. A good one from Finland is available below.
Frontiers | Nitrogen Recovery With Source Separation of Human Urine—Preliminary Results of Its Fertiliser Potential and Use in Agriculture (frontiersin.org)

For several years we have been using urine as a fertilizer, particularly on fruit and other trees, by the simple method of keeping a watering can (white, to fit in with the toilet décor of course!) beside the toilet. Whoever wants to donate (usually me) uses the watering can instead of the toilet.

Collection vessel in place

Once we have accumulated a couple of centimetres in the bottom of the watering can I dilute it approximately 1 part urine to 10 parts water. Although I have read that anywhere between 1:8 and 1:20 is OK, so I don't think that the dilution is ratio is critical beyond a certain point. In fact, Jackie French in her book 'Organic Control of Common Weeds' recommends undiluted urine which has been aged 24 hours as a weedicide, so fresh and diluted is the way to go.

Undiluted pee can be added to your compost pile and counts as a high nitrogen 'green' (as opposed to high carbon 'brown's) component. Adding pee to your compost may also act as an activator, speeding up the decomposition process.

Recently I have become concerned about the level of sodium in urine, particularly as our soil is somewhat clayey and sodium is detrimental to its texture. Also, unless regularly flushed through the soil, sodium can build up, resulting a salty soil that plants won't do well in. Some plants tolerate salt in soils better than others but I think the key is to not use lots of urine in one place for a long time, but spread the good news around! (more on this in an upcoming article).

Also, while the current opinion seems to be that urine is sterile, a study (see below) challenges this idea but in the end has determined that it is still safe to use as a fertiliser. However, if a pee donor is unwell, their pee should not be used, particularly on edible crops, as a precautionary measure and if the pee donor is on medications such as antibiotics or antivirals it would be prudent to flush rather than use their pee as fertiliser.

https://www.sciencealert.com/researchers-tested-large-scale-use-of-human-pee-as-fertilizer-and-here-s-what-happened

Should you have any doubt, I have read that people can kill any bacteria present merely by sealing up the fresh pee in a sealed container for weeks or months, allowing the urea to break down into ammonia and thereby killing off any errant bugs. What the studies don't mention is how badly the smell of the aged pee takes your head off when you finally open the sealed container!

*Dilute stuff being applied to a fruit tree using a **deep pipe waterer***

Anyway, the controlled and thoughtful use of your pee as a fertiliser as part of your fertility management program can help you recycle nutrients and replace some imported fertiliser, thereby allowing you to grow your produce more sustainably and productively.

4.3 Making Liquid Comfrey Extract

Comfrey is a very **easy to grow** and useful herb. Among other things it is a dynamic accumulator; that is to say it sends its long taproot down into the soil, brings up nutrients inaccessible to other shallower rooting plants and accumulates them in its leaves. There are a number of ways to make these nutrients available to other plants, the simplest being to cut the leaves regularly and leave them as a mulch under the plants you wish to fertilise. The leaves break down over time and the other plants get the benefits of the extra nutrients, but there is another way where you can concentrate or extract the nutrients in liquid form. This is how to build a gadget to do it.

The idea is to confine the comfrey leaves within a container and allow them to break down, applying a weight to provide pressure and extract the liquid nutrients from the leaves as they break down, then channel them into a container for use. To make the extractor I used some storm water pipe, some pipe fittings and a couple of 1.25 litre recycled soft drink containers.

The Pipe

While the diameter and/or length of the pipe isn't critical, the larger the pipe you have the more comfrey leaves you can fit in at any one time. I used a 1 metre length of 110mm outside diameter pipe. I use this because it was available, a good size to work with and fitted the soft drink bottle fairly snugly while still allowing it free movement. I had to buy in a couple of push-on end caps and a couple of purpose designed brackets

to allow me to mount the pipe on the fence, but that didn't amount to much and I found the rest floating around the house.

The extractor will be mounted vertically so there will be some weight on what will become the bottom end cap so I intended to glue that one on. Also, there should be no need to remove it.

The bottom end cap was also where the comfrey extract will be flowing out of, so I needed to install a delivery pipe before fixing it to the bottom of the pipe. I got hold of a garden hose tap fitting I had hanging around and placed on the centre of the bottom end cap. Using the tap fitting as a template I drew a circle around the edge with a pencil and then drilled half a dozen 6mm (1/4 inch) holes inside the pencil circle. I then fixed the tap fitting to the end cap over the drilled holes using silicone sealer. After giving the silicone 24 hours to cure, I glued the end cap onto the pipe using plumbers glue.

The top end cap was not going to be glued on because it did need to be removable to add comfrey leaves, install and retrieve the weight and to clean the pipe out when required. It is mainly there to keep rain out of the pipe to prevent it prematurely diluting the extract. I did drill a 6mm hole in the centre of the cap (location of the hole is not critical) so that I could run the string through the hole which is attached to the weight.

The Weight

From my original readings I thought that the weight was going to somehow force the juice out of the leaves as they were, but subsequent research has shown that the leaves have to decompose before the nutrients are extracted. I decided that the maximum weight would work the best. The 1.25litre soft drink bottle if filled to capacity with water would weight about 1.25 kilograms, or in other words basically the weight of the water. To increase the weight, I first filled the bottle with coarse sand, then slowly ran the water in so that it infiltrated between the sand particles until the bottle was full. The bottle now weighed 2.6 kilograms, which sounded to me like a good weight to do the trick.

All that was needed now was to tie some strong twine around the neck of the bottle, which I could use to lower the bottle into the pipe and then retrieve it as required. The free end of the twine was then run through the hole in the top cap, and the tied to a wire 'key-ring' style ring to prevent it slipping into the tube.

Installing the Tube

After casting around where to set up the tube I decided to place it on the north face of our southern fence, I figured a bit of warmth from the sun will help with the decomposition. I suspect that the location is not critical except to make sure that you can easily get to it and you can remove it when required. Being able to remove it from its mounting and turn it upside down to remove spent leaves will make the eventual cleaning much easier.

Our fences are colourbond steel so I lined up the brackets so that they were straddling a channel and the fixing holes were sitting on flat steel. The brackets need to hold the tube in a vertical orientation so they have to apply some pressure to the tube to prevent it slipping downward. I set it up so that the second plastic soft drink bottle

fitted neatly under the tap fitting on the bottom cap with a minimum clearance. I then drilled a pilot hole and screwed in two screws to the top bracket and two for the bottom.

To complete the job I placed some clapped out stainless steel mesh pot cleaner in the bottom of the tube to prevent the leaves from blocking the drain holes. It was then just a case of harvesting and packing the comfrey leaves into the tube and then installing the weight and the top push-on cap. I half-filled the tube with as many leaves as I could get with one harvest. It took about a week for some extract to drip down into the lower collection bottle. It is late summer here and I suspect you should allow more time in case you are doing this at a cooler time of year or in a cooler climate.

To use the extract, dilute it about 20:1 with water, apply around the base of the plants which you wish to fertilise and water in.

4.4 Making Bio-fertiliser on a Small Scale

Since the industrial revolution when the science of chemistry started to come to the aid of agriculture, our understanding of the nutrient requirements of plants has increased in leaps and bounds. To understand the truth of this you only need to look at the wide range of chemical fertilisers available at your local hardware or plant nursery, but the result of that knowledge is that we have focused on the provision of chemical nutrients to the exclusion of all else. We have forgotten what our ancestors knew, that a healthy soil means healthy plants and healthy plants give good yields. We have neglected the biological side of the equation, providing our veggies with the chemical elements they require but not nurturing the soil and soil microbiology.

This is all starting to change however and there is a big buzz around biological fertiliser, quite often shortened to biofert. These biological fertilisers can be home made and they ensure that the soil gets a charge of beneficial bacteria and fungi so that the soil and our veggies stay healthy and productive. They can be made using an anaerobic method, which requires some time but little equipment, whereas using the aerobic method is much quicker and there is not much equipment required.

The more “professional” larger scale set ups I have seen are based on a 200 litre drum but the biofert needs to be used quickly and I found that a 200 litre drum was just too big for a backyard set up. Plus we are not over flush with space around here so I set it up in an old 25 litre fermenter that I bought third hand for a few dollars some years ago and I believe that it is much more suited to the urban/suburban farmer.

What you will need:

- 1 x 25litre fermenter (or even just a 20-25 litre bucket)
- 25 litres of non-chlorinated water, I used tank water and that worked pretty well otherwise I suggest drawing the water then letting it sit for a couple of days so the chlorine can dissipate.
- 500g worm castings or well-made compost
- 200g molasses
- 20g fish emulsion
- 1 x fish tank aerator complete with flexible tubing and air stone, you could try pinching the one out of your wife’s goldfish tank, but I wouldn’t recommend it. I picked up my set up for less than $20 so they are not that expensive.

The theory is that you get some material rich on the right type of microbes (worm castings or compost, I used worm castings) and then dissolve them in water to allow the bugs to move into the water. The bugs will then start looking around for bug-food and you need to provide it by supplying them with a source of carbon (molasses) and nitrogen (fish emulsion) and oxygen as well, hence the aerator. You leave them until they have bred up enough and then add the bug-water direct to your plants. It's as easy as that!

1. I hunted around until I found an old hessian bag but any coarse cloth, including well worn pantyhose (come on guys, you can be honest with me, I'm sure you

have an old pair in the back of your sock drawer somewhere) and fill the 500gms of worm castings into it.

2. Fill your container with 25litres of pure non chlorinated water then use the bag full of worm castings like a tea bag and jiggle it around, then leave it to soak overnight. When you remove the "tea bag" next day the water should be somewhat darker but have a not unpleasant earthy smell.

3. Ok so the bugs are in, now it's chow time! Add the molasses slowly and with plenty of stirring otherwise it will head for the bottom of the container and form a pool that is difficult to mix back in. Once it is incorporated add the fish emulsion. I found that once the molasses went in the water had a mild molasses like smell (unsurprisingly) and having no real endpoint to shoot for I was going to run things until that smell went.

4. Next connect up your aerator and air stone. My fermenter had a hole in the top so I fed the clear air tubing through that and then connected the air stone on the other side. That way I could still put the lid on and keep out any unwanted additives, like one of our cats. It is a good idea to mount your aerator above where the tubing enters the container so that if there is a failure of some description the liquid can't siphon back into the aerator motor and make expensive noises or smells.

5. I turned the aerator on and the air stone proved to be too light and just bubbled back up to the surface of the liquid along with the air so I pulled it apart and slid a small nut along the tubing down to the air stone and this provided enough weight to keep the air stone submerged.

6. So I set the system to bubbling and left it overnight, it can take as little as 24 hours if the conditions are right and the temperature is 20°C or 25°C. It is winter here at the moment so the temperature in my garage can be 10°C or less so I

figured it would take a few days for anything to happen. Certainly when I checked the next morning there appeared to be no change.

7. The following morning, however, there was froth all over the place! OK, so there was a bit of froth coming out of the hole where the tubing passed through the lid, but it was enough to cause me to wonder what on earth was going on! A bit of research turned up that this WAS the end point and the biofert was ready to go.

To make sure the bugs stay happy and get where they need to be, apply them shortly after the end point is reached, apply them direct to the plants undiluted using a watering can rather than a spray and apply after the sun has gone down and is not shining directly where you are applying it. The bugs have never heard of sunscreen and the UV will kill them rather than improving their tan.

4.5 Making Fertiliser Sausages

First of all, credit where credit is due: I stole the idea from Annette McFarlane as described in her book “Organic Fruit Growing”, (check out page 43).

The idea is to find natural fibre (ie biodegradable) fabric which is no longer required, collect organic materials which will rot down to release plant nutrients then wrap the latter in the former to form long “sausages”. These sausages are draped around the drip line of fruit trees and bushes etc and act as slow release fertilisers. They are especially good for keeping stuff together and in place if your land is sloping, which mine is not, but I liked the slow-release part!

This is how I put mine together.

The Casing

In terms of the fabric “casing” of the sausage, a friend of mine has access to the hessian coffee bags which raw coffee beans are packed in when imported into Aus for roasting, which are then discarded. So if you want to do this the way I have check out any local coffee roasters and see what they do with their excess bags. Also if you have any local purveyors of organic produce, some of it (potatoes definitely) is shipped around the country in hessian bags.

The bags are made by being folded over and then sewn down the edges, when I get them they are already opened at the top so this is not an issue. To get the most out of each bag they need to have the sewing undone so that they can be opened out to form a piece of fabric 2 metres long. Most of the bags seem to be sewn with a hemming stitch, and you can either cut along it or unpick it from the edges. Either way takes a similar time but if you unpick it you get the twine and can use it to tie around the sausage to keep the filling in.

To fill the sausage, lay it out on the ground and heap some filling along one side, then take the edge closest to the filling, pull it up over the filling and roll it tightly so that you get the filling covered by one and a half to two turns of the material. To finish off, use biodegradable twine and tie it around both ends, with two or three intermediate ties to keep the filling from falling to one end during transport.

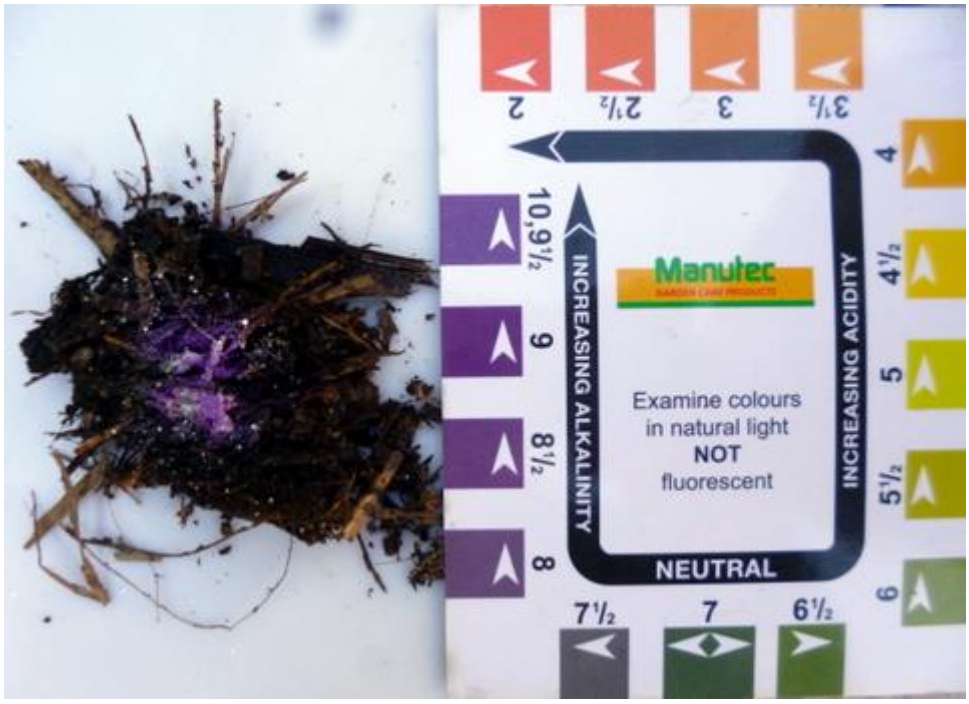
The Filling

The filling can be composed of whatever organic material you have available.

There is a place near us where the kids make pocket money by selling their pony poo, so I got a bag of that, probably about 25kg worth. The chook poo we produce is applied directly to the veggie patches by the chooks themselves, so I had to buy in a bag, also 25kg.

To make the filling I put half the bag of pony poo and half the bag of chook poo in my wheelbarrow, followed by 2 chook-food bags of our home made compost. To top it off I threw in 500lm of rooster booster (my daughter gave me a couple of bags when they moved), 2 x 500ml containers of wood ash for potassium from our fire and a handful of rockdust for trace nutrients.

The pony poo was pretty dry, so I gave it all a thorough dowsing and then a thorough turning with my garden fork, to the point where the mix was moist but not dripping.



The wood ash did bring the pH up to a bit over 9 but I only took a couple of grab samples to check and it was just after mixing so I think it will settle down over time.

Installation

Once the sausage is filled and tied it is just a case of dragging it into position around the drip line of a tree or bush. I have installed a run of fertiliser sausages around the inner circle of the fruit tree circle to provide a bit of extra nutrition come spring. I have also installed them in around a couple of other fruiting plants include our coffee bush.
I have also made some smaller sausages, using the same process as above, but not opening the bag out, just using it as is to provide a double layer of casing.

5.0 Compost and Bokashi

5.1 Composters I Have Known

Do you feel guilty every time an apple skin or the potato peelings end up in the rubbish bin instead of being recycled? Do you feel that you are depriving your beloved veggie garden of vital nutrients and are contributing to global warming and the filling up of our rubbish tips at the same time? I must admit to such worries and have had a number of shots at composting over the years, quite often without success. Following is an outline of the methods that I tried that didn't work or didn't live up to my expectations. None of the methods are my own invention but are ideas picked up from organic gardening books and magazines.

The classic method of making compost using the three bays, each capable of holding a cubic metre or more of compost (one freshly laid, one composting and one ready for use) is without doubt the best. However, in the average urban/suburban backyard it takes up quite a bit of space, can look unsightly and add to the atmosphere in an unpleasant way, but most of all is the problem of the amount of organic matter required to operate this system. Each bay would take months or even years for the average city dweller to fill, but the idea is to have all the materials ready to go and then build the pile in one operation. So for me this method was unsatisfactory, (This is what I thought up until a couple of years ago, but I shall refer you to the next section of the eBook for more discussion on this theme!) I needed a composting system that would not be too unsightly, not take up too much space, be able to deal with regular small additions of materials be hopefully inexpensive and produce good compost. No small feat you may imagine, but here is my journey towards compost heaven.

The Pit

This is one of the simpler composting methods and was the first that I tried. As the name suggests the organic matter is shovelled into a hole in the ground and then covered and allowed to break down. How low tech can you get? On most counts it did

pretty well, but the problem came with the first rain. We have clay soil and the rain seeped in and stayed, the result was a cold, sodden, stinking mass; some decomposition occurred but you couldn't call it compost. Back to the drawing board!

The Heap

This is perhaps marginally simpler than even the pit in that the organic material is dumped on the ground and then covered. The problems that I encountered with it were twofold. The first was that once the chooks discovered it they immediately set about distributing it for me, free of charge, repeatedly! The second and more serious problem was the perennial one of being unable to accumulate enough organic matter to build a heap big enough so that the heat generated did not escape through the sides. A heap that big would also have looked mighty untidy and lost me brownie points with my lovely partner in sustainable living.

The Inverted Garbage Bin

This is based on getting a plastic garbage bin, cutting out the bottom, inverting it and putting the lid on the hole in the bottom (which is now the top, if that makes sense...). When the compost is ready lift up the bin and bingo, there it is ready to be shovelled to wherever you want. All very well in theory but in practice the mass was not large enough or well insulated enough to retain its' heat and the result when the garbage bin was removed was a partially decomposed pile of yuk. There are other proprietary bins on the market that work on the same principle but they tend to be larger with thicker plastic walls and these may actually work but can tend to become a bit pricey.

The Partially Buried Garbage Bin

This is a similar idea to the one above but the bottomless garbage bin is buried to around half or more of its height in the ground, right side up. The idea here is to provide a degree of insulation using the earth that the bin is buried in so that a higher temperature can be achieved and maintained. Again, a nice theory but the clay soil has

its part to play and on the first rainy day water percolated up into the would-be compost and drowned it. This cold wet pile of rotting garbage was starting to be a mighty familiar sight, not to say smell.

The compost Roller

This consists of a metal drum on its side, elevated so a wheelbarrow can be fitted underneath to unloading purposes and fitted with pivots so the compost can be mixed by rolling. As a base I used a 205 litre drum due to low cost and easy availability. The rolling action introduced a new factor – the organic matter tended to form balls an inch or two in diameter that were fibrous on the outside and disgusting on the inside. Interesting but not very helpful. Again the main problem seemed to be lack of mass and/or insulation so the temperature could not build up for sufficient decomposition.

The Incinerator

For years we have been forbidden to burn off in our area and during this time the old cement block incinerator sat alone and unloved in a corner of the yard. It wasn't unsightly, was cheap to get (free actually), takes up a small amount of space and copes well with small to medium sized additions. It also retains the heat and drains well so the quality of compost wasn't bad, but a batch took a year to mature.

The Dalek

You know – Dr Who and all that – The square-ish, top loading black plastic bin that sits on the ground and you harvest the compost from little doors at the bottom that is commonly seen in back yards today. We had two and they gave us reasonable service over the years. They were in the chook pen but didn't get much sun so I transferred them down to the northern side of the southern fence and they worked tolerably well. They didn't cost a lot and produced a dense but well flavoured compost (well nutriented any way and the veggies never complained.)

The Aerobin

After our visit to Michael Mobbs place in inner Sydney and seeing the row of council owned Aerobins in the part near his place, as well as his one, we decided that that was the bin for us. It looks good, has reasonable capacity, built in air flow and insulation to retain the heat of decomposition, even in winter. After installing it and removing the old Daleks I put the non-ripe compost into the Aerobin and was surprised at the amount of heat produced, even in late autumn/early winter. It is a bit too early to be definitive but ti looks like it might be a winner.

2024 Aerobin Update

While the aerobin seemed like a good idea at the time, it was expensive (although I did get a second, preloved one as well) but the central aerator did not seem to work very well and short of pulling everything out and dumping it back in, there was no way to mix the compost. In the end I gave them away and went with the old faithful three-bin system. See the next section.

Compost hints

• Aerate your compost regularly by pushing a pipe down into it or digging it over.

• Where possible balance your nitrogenous materials like lawn clippings, veggie peelings fruit wastes etc with carbonaceous materials like straw, dry leaves, shredded paper or sawdust so that you get a ratio of about 25:1 carbon: Nitrogen.

• In my experience the “activators” you can buy don’t do much. If the pile is OK no activator is needed, if there is a problem the activator won’t fix it. Having said that it you MUST use an activator, try peeing in the compost, it adds nitrogen and may give it a kick start! (preferably at night when the neighbours aren’t watching.

• Don’t worry about adding lime, in a well managed compost bin the pH will take care of itself.

One more thing before I finish, if you read the books, especially the older books on veggie growing and composting, the thing you tend to see is that you should turn your compost over once it has had an initial heat up and break down time. The thing they say to do is to remove the compost from your bin then replace it such that the material around the outside is now on the inside and vice versa. The only comment I have to make on that is that the persons who recommend this practice have never actually tried to do it!

5.2 Our Three Bay System

Over the years I have tried many composting systems (previous thoughts can be read above) but for one reason or another, none really worked out for me. I had, of course, considered the classic of composting – The three bay compost system. This works by placing a mix of organic matter into one of the bays, letting it heat up and cool down, then turning it into the next bay along (then refilling the first bay with new stuff), allowing the material in the second bay to heat up and cool down, then turning the finished compost into the third bay, where it is ready for use. The process then continues.

I have always found it interesting that in the books, the way it is described that the material in one bay is turned into the other is that it should be done in such a way that the material on the outside of the pile, is placed on the inside of the pile. Makes may wonder if the people advocating it had actually tried to do it!

Anyway, I always seemed to find reasons for not giving it a go. Things like –

- We don’t produce enough organic matter to make it feasible,
- We don’t have enough room,
- It will look messy and crappy (to be fair this was Linda rather than me!)

Our council provides us with a green bin so for the most part our FOGO waste want in there, after removing some small amounts for the chooks and the worms, and grass clippings often being used as mulch.

It has taken a while but I have been noting lately that the green bin is quite often going out full. Trash from the banana circle including banana ‘trees’ that have produced and passed on, choko trimmings and all of it once it has died back over winter, mulberry trimmings and corn stalks (which could be shredded) as well as some grass clippings, prunings and other miscellaneous vegetable matter. Over time it all adds up and results in lots of full green bins which I could be composting myself and it seems that we do produce enough organic matter to run a three-bay system!

The area prior to cleaning and demolition

So the question was – where? We only have a 600m2 block and a lot of it is taken up with trees, water tanks, house and sheds, veggie beds, green house and so on. I had a

place earmarked for other things against the northern fence, but after much consideration I decided that it would become the compost area after some demolition. I spent a couple of months clearing the area in preparation and conducting said demolition. With the area cleared, it just remained to obtain some pallets (my choice of construction material for the bays) and put them together.

Oh no! It's full of crap!!!

Empty and ready for demo!

In general terms pallets are constructed of softwood or hardwood. Softwood pallets tend to be lighter (and therefore easier to work with) and quite often available free, but rot more quickly and need replacement more often. In contrast, the hardwood pallets are quite a bit heavier, can be more difficult to come by/expensive, but last considerably longer. My dilly dallying about getting hold of the pallets was sorted out by the kids, and a nice load of hardwood pallets arrived in time for Father's Day (2023).

Raw materials arrive

Deniz came to give me a hand putting it up. First we stood the pallets up to work out the best configuration, which turned out to be run a continuous wall of pallets along the back and then attach the side pallets to that. We then moved the pallets away to dig out a bit of dirt so that the pallets along the back were straight and level. With the pallets along the back in place and steadied, we put the first side pallet in place and screwed in a couple of brackets to hold it, then did the same with the next side pallet and so on until all four were secured in place with two brackets per pallet, per side.

Looking along the back

Bracket close-up

A part of the area where we were installing the compost bins was covered by pavers, which helped to keep the pallets level so I didn't remove them entirely, but I did remove some from the middle of the bays to allow the compost contact with the soil, so that the soil biota could help with breaking the organic matter down and forming compost.

Pavers removed

It is semi-finished, because I do want to set up and install some slats on the front of the compost bins to stop material from spilling out the front, as a friend of mine has done (see pic below). He also harvests material from his constructed wetland to be added to the compost pile, which would otherwise go off site to be composted, which I hadn't thought to do.

Amazingly enough, though Linda was concerned that the compost bins might look scrappy, even she was pleased with the compost bin visuals and noted that they tidied up what had been a messy area previously.

It is surprising that once the compost system is there, you start to see things that can go into it straight away, and what was a waste material before has become a resource. I have been packing in dead choko vine, banana trash, grass clippings and peelings etc. I was even able to make use of an unwanted area out the front of a neighbour that was producing a very nice white clover crop by mowing, then incorporating the clippings into the compost,

A lovely (if unwanted) stand of white clover, now harvested and in the compost bay

Another happy thing that I wish I could say I planned but was sheer coincidence, was that because of the compost bays' closeness to the greenhouse, materials like dead plants, excess filled newspaper pots and leftover seed raising mix from punnets, can now directly into the compost instead of a heap outside the greenhouse door.

So, now I look around with a new eye for compostable material, Linda is happy because the area looks better and I am pleased because material which used to go offsite (albeit to commercial composting) is now retained here and the fertility it generates will help us grow better veggies. Everyone is a winner! (except maybe the council, who gets less in their green bin, although I could not bring myself to add used cat litter to ours so the council still gets that!)

5.3 Making your own bokashi bin

What on Earth is a Bokashi bucket?

It is a small scale food composting system that uses an air tight bucket and special micro-organisms to break down the food and it does so without the yuk factor of the disgusting smells usually associated with anaerobic decomposition. It will also handle some materials that are verboten in normal composters and/or not particularly enjoyed by worms such as onions/garlic, citrus rinds and uncooked/cooked meat. They are ideal for those living in the city and suburban environment that want to compost their waste but are put off by the associated stink and hassle. Does this interest you? If so, then read on!

Making the Bokashi Bucket

Of course it is possible to go out to Bunning's or wherever and pick up a commercial Bokashi bin, but they can cost over $70 and if you are a bit short of cash you can make yourself one for a bit over $10, or less if you have any 20 litre buckets already hanging around.

1. Get hold of the raw materials – 2 x recycled plastic 20 litre buckets with tightly fitting lids, a valve and hollow bolt to go through the side of the bucket. The big hint, particularly if you are using recycled buckets, is to ensure that both buckets are the same size otherwise even a small difference in size can mean that when they are put one inside the other there will be a gap meaning they are not sealed, or they can seal so tight you can't get the buggers apart when you need to!

2. Pick the bucket that you are going to use as the inner bucket and drill some 6mm or so (it's not critical) holes in the bottom to allow excess liquids to drain off.

3. Get hold of the outer bucket and drill a hole as low down the side of the bucket as you can the same size as the hollow bolt or a bit smaller, I used a speed bit and my battery drill.

4. Insert the hollow bolt through the hole form the inside out, wrap the threads in Teflon tape (plumber-on-a-roll) and then screw the valve onto the bolt and tighten up. At this point it is best to test your seal by putting some water in the bucket and checking for leaks around where the valve goes through. If you don't do this now you may find unmentionable fluids leaking onto your floor and it will be much more difficult to fix. If you do find some water leaking out when you test it, run a bead of the appropriate silicon sealer around where the valve comes out and allow to dry.

5. The material in the bucket must be compressed to remove air spaces so you can make a tool to do this from the second lid, which will not be needed. Measure the bottom of the inner bucket and then draw a circle the same size around the lid using a pair of dividers. You can then cut out the circle using a band saw or jig saw. The plastic top is still a bit flexible to effectively compress the organic material so I grabbed a couple of pieces of recycled 70mm x 20mm DAR and cut two lengths the same diameter as the plastic disk, I then cut a jigged edge lap joint so that the timber formed an X. I screwed the X to the back of the disc and the tool, was ready to go.

6. I grabbed some pieces of scrap timber that I had lying around and cut them to size and screwed them together so that I had a box to sit the whole assembly on to get it off the floor and give better access to the drain valve.

7. The DIY Bokashi bucket was ready to compost (or bokash, or whatever you call it....)

Operating your Bokashi Bucket

1. When you start out, place a 3cm to 4cm layer of your finest veggie scraps etc in the bottom of the inner bucket, then add in a layer of the Bokashi material, which you will need to buy from a hardware store or other supplier. This is one of those rare times, like eating chocolate, where more is better so don't skimp, if in doubt add more. In any case at least a handful per layer of organic matter.

2. Take your faithful compression tool in hand and press down on the organic material to push all the air out. If you want you can leave the tool sitting inside the bucket on the surface of the organic material, I certainly do.

3. Replace the lid on the inner bucket making sure that you have a good airtight seal, because this is needed to reduce the oxygen inside the bucket to get the Bokashi doing its thing.

4. Just repeat steps 1 to 3 every time you get some organic material until the inner bucket is completely full, making sure you put plenty of bokashi material in the last addition before sealing.

5. During this time you should regularly open the valve on the bottom of the outer bucket to drain off any liquid, preferably into a container, the pour it onto your garden beds as a liquid fertiliser.

6. Then seal up the top and leave it for two weeks to finish “Bokashing” (which is a fermenting type process), regularly draining off any liquid as in step 5.

7. Having a second set of bokashi buckets at this point would be good, but otherwise if you don’t have too much organic material accumulating you can freeze it and use it to start up the next bucket once it is empty and clean.

8. Once the bucket has finished Bokashing you can use the output for a number of things (See the next section) and once the bucket is empty, clean it out thoroughly and it will be ready to go again either when you other bucket is full or to start now with your frozen stuff.

Any Problems?

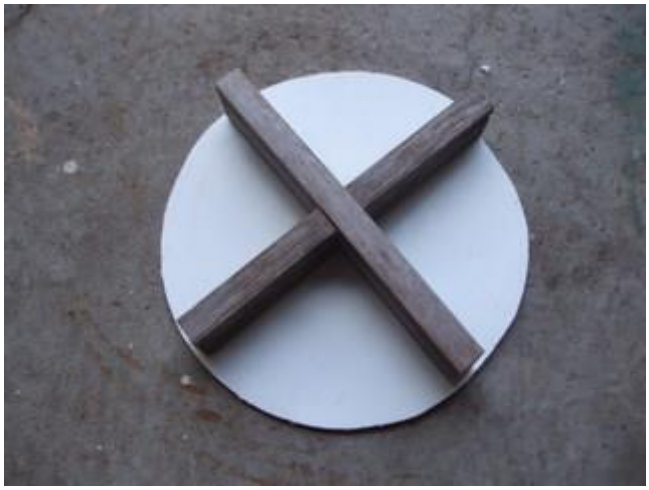
If you bucket has not been doing what it is supposed to you may start to get anaerobic decomposition that produces the characteristic rotten egg smell or it may show the presence of black or blue green fungi, and this may be due to one or more of the following causes –

- You haven't put in enough bokashi material between additions of organic matter, remember more is better!

- You haven't drained off the liquid often enough and it is flooding the organic material, although with the larger reservoir of the home made bokashi bucket this is unlikely, it is still possible.

- The bucket lid has not sealed adequately, this is why it is important to make sure your lid seals before you make your bin and to always ensure you seal the lid tight after adding more organic material.

- The bucket has been too hot or too cold for a prolonged period of time. Again this is unlikely if you keep your bucket inside, but don't stick it out in the shed particularly if you are subjected to the 42°C that we get here in a Western Sydney summer!



Now What Do I Do?

Now that you have the output of your Bokashi the question is what can you do with it? And there are a number of options –

- Add it to your existing outdoor composter if you have one.

- Add it to a worm farm if you have one of those.
- Dig it in directly into one of your veggies patches as is.
- Use it to attract black soldier flies. This is the stuff of a whole ‘nother article but briefly you can use you bokashi output in a commercial or homemade black soldier fly larvae farming set up. This set up induces the black soldier fly to lay eggs in or around vegetable waste then captures the larvae (maggots) as they go looking for soil to pupate in. The maggots can then be fed to chooks or fish in an aquaculture system. I have found that the bokashi material attracts black soldier fly like nothing else!

Helping your Bucket do its work

- Do not add water, milk, juice or other liquids to your Bokashi bucket
- Keep the lid firmly sealed at all times
- Cut up any large lumps of organic matter to facilitate packing down
- If you only get small amounts of organic matter you can freeze them until you have enough to make a 3-4cm layer
- Don’t put paper, plastic wrap or meat bones in your bucket
- Keep the bucket in the shade

The only real down side to the Bokashi system is the continuing outlay on the Bokashi material itself, and I have read that it may be possible to home produce something similar, but I haven’t tried it so more research is needed. Watch this space!

Update 2012

No I haven't gotten around to making my own bokashi stuff yet, but the bucket itself is still in daily use. I must admit that I was never happy with the tap in the original design above, it is just too expensive. I have done a couple of workshops on composting which included making a Bokashi bucket and in the lead up to those I spent some time wandering around the local hardware shop to try and come up with something just as effective but cheaper and lo and behold I did! There are black plastic taps made to

screw into 20 litre plastic cube shaped liquid storage bottles but need to be secured in the bottom of the bucket and if you get hold of a 25mm plastic female plumbing connector it will screw straight in. You don't even need the full length of the connector so you can (as I did) saw them in half with a hand saw or band saw and use one connector to fit two bokashi bins with taps. Just drill a 25mm hole in the bottom of the bucket with a speed bit, push the threaded bit of the tap through into the bucket and screw on the half 25mm connector on the other side to secure the tap. It works pretty well but even so I would run a bead of silicone around the outside of the tap seal, just to make sure, so you don't get any Bokashi water making a break for it. Good luck!

6.0 Chooks and Worms

6.1 The Chook Tractor

As I have mentioned elsewhere, I have never claimed to be the sharpest tool in the shed but I do know a good idea when I see one, and my world changed when I came across the concept of the chook tractor! I found out about chook tractors through Bill Mollison's permaculture work somewhere 20 years ago and as soon as I saw it I knew I had to have one!

The advantages of a chook tractor were –

- It would allow me to make the best use of the chook poop by having the chooks directly apply said poop to each veggie patch in turn,
- Their scratching would shallow cultivate each patch, after which I would apply mulch and the worms would come up to the goodies on the soil surface and finish the job. No more rotary hoeing or double digging for me!
- The chooks were isolated from the wild birds thus solving the second and third issues referred to above.
- Due to their constantly being moved onto new ground, there was less likelihood of the chooks suffering from a build-up of pests or diseases.
- The chooks could make use of leftover vegetable and weed trash and harvest any residual snails, slugs and other bugs thereby reducing my workload and improving their nutrition.
- It looked great! By this time the old chook shed, Which was designed for a one way trip to Aust. full of glass beads, was now over 10 years old and looking pretty shabby so the chook tractor was a marked improvement.
-

Of course, the chook tractor would also impact on how we grew our veggies. Originally, I would just move the tractor around the several large beds (4m x 4m and 6m x 6m) we had at the time but I wound up dividing each veggie patch into beds 1200mm by

2000mm, which coincidentally is the footprint of the chook tractor! I have since increased half of the beds to 3000mm long, but that is another story.

Chook Tractor 1.0

I made this for the most part out of a deconstructed timber bed we were removing from the house and I built it to be able to take a direct hit from a thermonuclear weapon. It was solid! One half was covered, with the roosting and laying areas in that end as well as the door to the main part of the tractor and a separate door to the laying area. The other end was completely open, just covered by fairly strong chook wire.

It did the job well, but it was just too heavy! I wanted to ensure the chooks safety in case a marauding dog got in, but our backyard is well fenced and very secure so it never happened, I had made it extra heavy for no reason. Another problem was that the main door allowing access into the tractor was hinged at the bottom so that its natural position was down and if I didn't latch it properly and it got loose it would flop down and let the chooks out. Of course when this did happen the chooks would spurn their current patch and make for the most recently planted bed and devour all of those fresh, tender little seedlings. It was rare, but happened enough that I knew the next design would have to be different. Eventually it collapsed due to rot and I took some of the original parts and re-did it!

Chook Tractor 2.0

This one was also made of timber, but the nesting/roosting area was all in the top of the tractor, accessible through a flap that lifted up and was hinged at the top so that its natural position was down (with the result that there has been no unauthorised digging in the patch by chooks since!). To reduce weight I used smaller lighter, timber (DAR pine mostly) and lighter chook wire. Also to save weight and improve ventilation, the

entire lower part of the tractor was surrounded by the chook wire. To improve the aesthetics yet again, and help it last longer, the entire tractor received a coat of British racing green paint. I also installed a set of handles at each end to facilitate moving it.

As performance goes, it worked every bit as well as the previous one, almost, but was much lighter. As time went on however, some flaws in the design did show up, particularly in hot weather. One difficulty was that with the bottom area entirely surrounded by chook wire, there was very little relief from the western Sydney hot afternoon sun, almost no shade at all. This meant the chooks had to take refuge in the top roosting section, whereupon the other issue became obvious. That lovely British racing green top area sucked in the heat and got much too hot as well. In the end I wound up tossing some shade cloth over the whole thing to try and cool it off.

Also, it only lasted a few years and, as usually happens with such things, collapsed at a very inopportune moment while I was at work. Thankfully Linda was able to shepherd the chooks back in and secure it until I got home.

Chook Tractor 3.0

While the basic design for this iteration of the chook tractor was similar to the one before it, I made a couple of important changes. The first of these was to extend the non-opening side of the roosting/laying area down to almost the bottom frame of the chook tractor, filling in the small gap left with a bit of wire. With this in place, depending on the orientation of the bed the tractor was on, could be faced north or west in hot weather to provide a cooler, more shaded environment for the chooks. The second change was that the whole thing was painted a nice, reflective white – three coats! That should stop the bugger rotting and falling apart!

Alas, it was not to be and after 5 years of constant use, it also fell apart due to rot.

Chook Tractor 4.0

The design for chook tractor 4.0 is almost exactly the same as for 3.0, with one significant change. Rather than using DAR pine and paint the living daylights out of it, I use aluminium angle! While being light and strong the 25mm x 25mm x 3mm thick aluminium angle in contact with the soil is absolutely resistant to the rot that killed the other three. I put it together three years ago and the wood covering bits could do with a bit of paint but the aluminium frame is in just as good a nick as when I built it!

6.2 The Worm Bath

I have a stacking plastic worm farm but it was never much of a success, partially due no doubt to lack of attention on my part but the worms never seemed to do very well and anyway I needed something bigger. After reading "Organic Growing With Worms" by David Murphy, I liked his design for a "neverfill wormery" but it was all constructed out of "Ammoniacal Copper Quaternary" treated timber, and at about $1.60 per linear metre (well the stuff that I found was) it would have been a very expensive worm farm, and contain very little recycled materials.

I had intended to site the bath between the new greenhouse and the first veggie patch, not ideal because the site was very exposed, but the space was there and it was accessible. Then it occurred to me that I should construct it inside the second "goat" shed. There are two well ventilated sheds against the north fence that one day may house a goat or two depending on lots of factors, but I would like to have home produced milk and cheese. One is currently the deep litter chook shed, the other is untenanted (except for the spiders!). The worm bath is very sheltered in the shed and if I ever do get the goat(s) I won't have to transport the manure very far to compost it. Having decided where to site the bath I then made a support frame of 100 x 100mm oregon timber left over from the veggie patch surrounds and then dragged out the bath.

The bath itself was an old Malleys one, it was a short one at 1300mm long all up rather than the more conventional 1500mm or so long. It is of the standard enamelled steel construction bought for $25 from a local recycler.

The original design called for one row of slits around the bath for ventilation, but I put in three rows all the way around the bath because of the importance placed on getting gas exchange by David Murphy. I also made no provision for harvesting the leakage (the so called "worm wee") because in David's book he argues that it rapidly becomes anaerobic, smelly and unhealthy within a week or two so is useless. He says that the

liquid manure should be made by dispersing mature worm castings in water. Taking this into account made the job a bit easier because I was trying to work out a way of getting the worm wee out easily, now all seepage and be absorbed into the ground directly below the baths' plug hole.

Before I could set it up I had to make the cuts in the side of the bath with an angle grinder. This is a fun job that is noisy as buggery (not to be contemplated before midday on a weekend lest your neighbours lynch you!) and emits showers of sparks that HURT if they hit unprotected skin, but are entertaining to someone watching you from a distance. I put in three layers of ventilation slits, about 45 to 50 all up, and went through about half a dozen disks doing it. The 100mm angle grinder also got mighty warm so I had to have about 3 bites of the cherry to get it done. The warmth may have been because the angle grinder (like me) is getting on a bit, but it was a fair job of work to do.

Once the bath had been cut and was set up in the shed, I put in about 30mm of gravel over the bottom for drainage, I used crushed terracotta as the gravel but I am sure almost any kind would do. Just before doing that I put a small piece of sarlon over the plug hole to prevent the gravel going AWOL. The gravel I then covered with sarlon (better drainage than weed matting) to separate the worm castings from the gravel.

Then went in a layer of shredded paper obtained from work and then a layer of broken-down straw and chook poo from the deep litter shed. Both materials were soaked with

water first by placing the materials in a wheelbarrow, spraying them water from one of the tanks and mixing and massaging the materials in the water by hand.

Finally a layer of cow manure was placed over the top. I picked up 1000 tiger worms from a local supplier and placed them on top of the manure layer and they seemed very happy to dig down into it. It was finished off with a sheet of wet hessian sacking to keep the top of the bath moist and give the forms some protection when they come up to the surface to feed.

Here's what it looks like after couple of years continuous use.

I feed the worms about once a week, during the week we save up veggie scraps and peelings and over fruit and veggie waste in the freezer, I then thaw them out on Saturday and feed to the worms. The freezing starts to break down the cell walls, making it easier for the worms to ingest. I only put the feed on one half of the bath, harvesting the other side to make seed raising mixture and potting mix from. Once one side is exhausted, I fill it up with cocopeat and move the feed over to that side. Give the worms a week to migrate and then the worm castings are ready for use.

6.3 The Worm Tower

When I constructed the fruit tree circle, I just put a chook statue in the centre, but after doing some thinking and reading I decided that the chook could sit on top of a worm

tower. A worm tower would keep the area moist and provide nutrients for the inner circle of red currants and the fruit tree circle proper. But what is a worm tower? I'm glad you asked!

A worm tower is merely some wide tube or pipe, with holes drilled in the end, planted end-on into the soil and then stuffed full of compost worms. You regularly put some organic material into the tower in the same way you would any worm farm, but in this case the garden plants harvest the nutrients directly through the soil without any need for you to collect and distribute the worm castings. Simple!

Another advantage for those of us who are .....let's say a bit more of a mature persuasion, the tower can be made so that it sits up half a metre to a metre above the ground (as this one is) so that you don't have to bend over to empty your veggie scraps into it. Convenient!

I was lucky in that an old plumber mate of mine dropped off some 30cm diameter plumbing pipe that was regarded as excess on one of the jobs he was working on and

was to be thrown out, so thoughtful chap that he is, he saved it and brought it to me.

How I Made Our Tower

While is suspect the exact amount is not critical, the bit that goes in the ground should go down 30cm to 50cm and be filled with holes. This is so that the garden worms can get in to share the bounty and the compost worms can get out and go on holiday if they want to (although they usually don't seem to want to).

The pipe I had was too long so I cut off a 1 metre section so that 300mm would be in the ground and 700mm would be above. The section that would be below ground needed to have the access holes drilled in it so using my (solar charged) battery drill I drilled a stack 0f 3/8" (about 10mm) holes all around the bottom. I drilled the holes on roughly 50mm centres but in reality, apart from the line around the pipe marking off

the 30mm level, none of the other holes were measured I just drilled them where they looked reasonable.

I had bought a terracotta plant pot saucer to go over the top of the tower to keep rain and light out. Worms only work in the dark so a cover is important, as is making sure all the drilled holes are under ground, keeping the inside of the tower light free. With the addition of the saucer, the tower construction part was completed, now for the installation.

How I Installed It

OK, so here is a hint. When you have a mind to make yourself a worm tower, make sure the place you want to put it can be easily got at and easily dug. While my idea was good in theory, it would have been much easier to install the tower BEFORE the fruit tree circle want in, not a couple of years later! Anyway, the centre of the circle was somewhat difficult to access but after some expert pruning I had a way in to be able to dig the hole. Another issue that I had forgotten about was that the centre of the circle was built up to cover the remains of the carob tree stump, which was there previously.

After being under ground for a few years you would think the thing had rotten away..... but apparently not.

If you have hole digger a bit bigger than the tower it works wonders but I didn't so it was really a case of dodging between the trees and starting off the hole by hand with a trowel. After having the living daylights scratched out of me by the kaffir lime on one side and the macadamia on the other, both got trimmed back even further to make a safe accessway. Fortunately the carob stump was off to the side and after several close encounters with the pick it didn't seem tom want to hang around anymore. Once I started to get down a bit I used a pick to break up the bottom of the hole, and then scraped it out by hand with the trowel again. It was reasonably hard work but better access would have made the job a lot easier.

Once I got about two thirds the way down (about 200mm) I filled the hole up with water and then let it drain out. This did two things; it made the soil in the hole softer and easier to dig but also showed me how quickly the hole would drain in heavy rain. In the event it drained in a few minutes and this was a good thing because while the

worms like a moist environment if it floods they will not be happy and quite likely decamp for pastures greener.

It was then just a case of completing the excavation and then trying the tower in to ensure that all of the holes I had drilled would be covered when the dirt went back in. To make sure it looked OK I used a spirit level to make sure it was vertical then scooped some of the fill dirt back in around the area between the tower and the edge of the hole. After packing it in a bit around the tower and watering it in, it gave the tower a solid foundation.

Installing the Worms

With the tower now in place and steady, it was time for the worms to be added to their new hi-rise home. Once the tower was stabilised I tossed in –

- a (9 litre) bucket's worth of well dug over straw (with just a hint of chook poo) to help with drainage;

- on top of that a bucket of well wetted down paper went in to provide moisture and something for the worms to chow down on.
- Then a bucket of cocopeat for the worms to live in,
- Then the worms themselves,
- A bit more cocopeat to cover, and then once they had settled in a bit;
- Organic waste (veggie peelings and stuff) which will start them off on their main food.

Now all is well and it is just a case of checking them every few days and adding more organic matter once they have chewed through the last load. Simple and convenient!

7.0 Resources

7.1 Books about Soil

Soil Food – Jackie French – Aird Books (AUS) 1995 ISBN 0 947214 44 5 – This is a good basic book on soil fertility. It starts off with correcting soil deficiencies and a discussion of pH then moves onto which plants need what elements then moves on to fertilisers (organic and inorganic) and how to use them. There are then 4 chapters talking about a different fertility maintenance technique in each one: green manure, manure, compost and mulch. The last chapter covers case studies in fertility management in particular circumstances such as new gardens, gardening on steep slopes, established fruit and veg gardens, dry gardens, eroded land etc. The book has a few line drawings.

What's Wrong with My Soil? – Kevin Handreck – CSIRO (AUS) 1978 ISBN 0 643 02169 8 – This booklet is part of the CSIRO Discovering Soils booklet series, but this is the only one in my collection. It is only 28 pages long and covers 3 types of soil problems – chemical, physical and biological. The first section on chemical problems is a good summary but looks at inorganic fertilisers to fix problems. The second section is much smaller and covers a bit about clay soils well and also mentions soil temperature and shade as physical problems. The biology section is more about pests and diseases, not much on soil biota. The booklet has colour and B&W photos as well as line drawings.

Managing Soil Without Using Chemicals – Jo Readman – HDRA/Search Press (UK) 2004 ISBN 1 84448 011 9 – This is a good book for the UK with limited application in Aus (as far as soil type info). It coves what soil is and talks about what soil is made of, soil life, the different types of soil and soil structure. The next chapter covers how to manage your soil including organic matter, cultivating your soil, pH and soil nutrients, and drainage. There is a section in the back on soil problems at a glance. Lots of colour photos and line drawings.

Australian Soil Fertility Manual – Graham Price (ed.) CSIRO & Fertiliser Industry Federation of Australia (AUS) 2006 ISBN 0 643 09021 5 – As you would expect from the publishers, this is main stream agriculture and not in the slightest bit organic! However, it does have a lot of information about soil nutrients and what they do in soil. Nitorgen, potassium and phosphorous get a chapter each, then another chapter on calcium, magnesium and sulphur, and one for micronutrients. There is some on soil, water and plant analysis for nutrient determination and also on fertilisers and the environment, including the impact of heavy metals. A few line drawings and lots of tables.

Teaming with Microbes – Jeff Lowenfels & Wayne Lewis – Timber Press (US) 2010 ISBN 978 1 60469 113 9 – If you are interested in soil, You Need This Book! It summarises the scientific research of the last 15 years or so (prior to the writing of the book) on the importance of the soil biota (soil life) and how it is crucial to the plants we grow. The first half of the book covers the different types of life in the soil and their impact on the soil. The second half talks about how you can apply soil web science to your soil and plants to get the best outcome. There is even a cheat sheet at the back summarising the important points in applying the science, but it is worth reading cover to cover and is a great read. Lots of colour photos and line drawings.

Teaming with Nutrients – Jeff Lowenfels – Timber Press (US) 2013 ISBN 978 1 60469 314 0 – This is the second book in the series and I found this much heavier going. It starts off with biology, botany and plant cells then covers plant nutrients and how they (and water) move through plant cells. Subsequent chapters cover the importance of soil testing and the factors affecting nutrient availability for the plants (eg pH), culminating in the final chapter on what and when to feed plants. The book is organic in approach and the as chapter provides organic fertiliser recipes for annuals, veg, perennials, trees etc. and how best to apply them. Lots of colour photos.

Teaming with Fungi – Jeff Lowenfels – Timber Press (US) 2017 ISBN 978 1 60469 729 2 – This is the third (and currently last) book in this series. Again, this gets quite technical and if you anything like me you will have lots of fun trying to pronounce the names of the various mycorrhizae! The book covers the impact of mycorrhizal fungi on

agriculture, horticulture, silviculture, hydroponics and lawns. There is also a chapter on how to harvest mycorrhizal fungi from nature and then grow it at home so you can then use it as an inoculum to grow healthier and more productive plants! Some line drawings and colour photos.

The Ultimate Guide to Soil – Anna Hess – Skyhorse Publishing (US) 2016 ISBN 976 1 63450 770 7 – This is a great "first book on soil" for the beginner, although some of the more specific stuff on soil types will apply mainly in the US.. It starts out with a series of soil tests that can be done at home to help you characterise your soil, following by recommendations on professional soil tests. The second part covers small scale no till basic techniques including starting a no till garden, solarisation, no dig management techniques and even aquaponics. The third section covers balancing nutrients (organically) and pH and the fourth section covers organic soil additions like compost, manure and wood chips. Lots of colour photos.

Caring for Soil – Alec Bulford – Kangaroo Press (AUS) 1998 ISBN 0 86417 918 9 – A good general book with a small amount of information on a large amount of soil aspects. The introduction covers information about characterising your soil then there are chapters on salinity, compost and water in your soil. The book then moves through information on the major nutrients (N, P, K) then covers lime and biochar (called agrichar® in the book). It finishes off with a discussion on soil carbon, soil silicon, garden pests and potting mixes. There are a few colour photos.

Soil Science for Gardeners – H. E. Maddox – Freshnet Press (AUS) 1998 ISBN 0 9593361 8 4 – This one is a bit more on the technical side but still understandable by the interested layman. It covers mostly the physical and chemical aspects of soil with almost no mention of soil biota. The section on fertilisers is not particularly organic although organic matter in the soil and compost is covered. The section on fertilising recommendations for vegetables, fruit and flowers refers to chemical fertilisers only.

The Living Soil – Janice R. Corbett – Martindale Press (AUS) 1969 ISBN not listed – This one is a high school general text on soil and soil formation all over the world. As one would expect from its age, there is no mention of soil biota at all, it is the physical and chemical aspects of soil and its formation which is covered.

Soils in the Australian Landscape – Ann and Robert Young – Oxford University Press (AUS) 2001 ISBN 0 19 551550 1 – This is a "big picture" book rather than a backyard soils book, but is sets the context of how a local soil fits into the soils of Australia. The book starts out with a discussion of Australian soils in general and the processes of how they were formed, how soils are characterised and named and the features of Australian soils in various parts of the continent. This is followed by sections on how water interacts with the soil and microorganisms interact with the soil. There are then chapters discussing old and hard soils, soils of high agricultural value, soils of forests and rangelands and finally soils around cities. There is a two page appendix on nifty soil tests you can do at home to assess you own soil. There is a section giving 32 colour plates and a few line drawings.

Soil Fertility – C. E. Millar – John Wiley & Sons Inc. (US) 1955 ISBN 978 8176221 13 9 – This is my copy, but it seems that it was been reissued in another format in 2013. This is a fairly comprehensive and scholarly work on soils, covering soil nutrients, colloids, pH, organic matter, NPK, calcium, magnesium and sulphur and the micro nutrients. There are also chapters on soil deficiencies and determining plant nutrient needs, soil organisms, green manures and crop residues, animal manures and commercial fertilisers. There are also two unusual chapters at the end, one on rotations and farming systems and the final one a summary of old US field experiments from the late 1800s and early 1900s. Probably not much use to the backyard grower but interesting nevertheless. The book has a very small number of black and white photos and the odd line drawing or table.

7.2 Books about Compost

Composting : A Study of the Process and its Principles – Clarence G. Golueke PhD – Rodale Press Inc (US) 1972 ISBN 0 87857 051 9 – If you are after a techo composting book, this is it! It does go through the process in considerable detail with only a graph or line drawing or two to leaven the text. It is a bit dry and some of it is more about an industrial process rather than the home garden, but there is a section on home composting according to the University of California method. Good luck!

Let it Rot! – Stu Campbell – Garden Way Publishing (US)1990 ISBN 0 88266 049 7 – This is a good one, it talks about how to build and where to site a compost bin, covers the raw materials used and what you can use the compost for when it is finished. There is some technical discussion about the process of composting but not so technical I couldn't understand it so you should be fine. There is also some discussion of composting on a larger scale. No photos but a few line drawings.

Backyard and Balcony Composting – Mark Cullen and Lorraine Johnson – Bookman Press (AUS) 1992 ISBN 1 86395 027 3 – This was originally a Canadian book but has been adjusted to Australian conditions. It is another good one covering the how and why of composting, the various types of composter available and how well they work , what should and shouldn't go in as well as a section on troubleshooting. The book does cover the issues with composting in small scale balcony composting, but applies just as well to backyard composting. No photos but good line drawings.

Resurrection in a Bucket – Margaret Simons – Allen & Unwin (AUS) 2004 ISBN 1 86508 588 X – If you are after a compost book that
is really a narrative you can read from end to end, this is the one. There is lots of info and stuff on the history of composting and about the authors particular composting journey. Good book but no photos!

Recycle your Garden – the essential guide to composting – Tim Marshall – ABC Books (AUS) 2008 ISBN 978 073330984 7 – A very good and comprehensive Aussie book that covers building a compost heap, compost ingredients and tools, using worms, anaerobic composting and solving compost problems. Nice drawings and lots of colour photos.
No Garbage: Composting and Recycling – Allen Gilbert – Lothian Publishing (AUS) 1992 ISBN 0 85091 485 X – A good basic Aussie book, plenty of line drawings and some colour photos. The book covers composting how, when and why; soil structure; composting methods; volunteer and community gardens; using compost in the home garden and more. This book is part of the Lothian Australian Garden series.

The Compost Book – David and Yvonne Taylor – Reed New Holland (AUS) 2004 ISBN 1 87633 428 2 – This is a small book with a few colour drawings and rather than being set out in chapter is arranged under headings alphabetically in the manner of a dictionary, making reference fairly easy. There is a paragraph or two on each entry so this is not an in-depth technical discussion but good for those just starting out.

7.3 Books about Worms

Organic Growing with Worms – David Murphy – Viking (AUS) 2005 ISBN 0 670 04174 2 – an excellent Aussie book, lots of useful information. The first section covers worms for everyone and provides a general introduction broken up into earthworms generally, their classification, soil fertility and vermicast. The second section covers worms for gardeners and how they are used, and worms for fisher persons. The third section covers worms for farmers, including large scale vermiculture, earthworms and biodynamics and earthworms and dung beetles. Section four covers worms for worm farmers about starting a worm farm. The fifth section covers worms for the greenhouse covering how worms can fight global warming and how they can be used to process sewage. The final section covers worms for waste managers, how worms can be used to manage waste and guidelines for best practice in worm waste management. This is a must have book for Aussie worm farmers. The book has some line drawings and a central section of colour photos.

Earthworms for Ecology and Profit (Volume 1: Scientific Earthworm Farming) – Ronald E. Gaddie & Donald E. Douglas – Bookworm Publishing Company (Can) 1977 ISBN 0 916302 05 9 – There was a volume 2 brought out in 1977 - Earthworms and the Ecology – but it seems much rarer than Volume 1. This is a technical book for those serious about the business of worm farming. The book starts out with an introduction about worms and starting a business based around earthworms. Chapter two is an in-depth technical review of earthworm anatomy and lifecycle. Chapter covers planning and setting up your earthworm business including site assessment, outdoor bed and shelter construction and initial care of beds. Chapter 4 covers earthworm feeding and feeding methods, chapter 5 pests and diseases, and chapter 6 general earthworm care. The following chapters cover harvesting and grading, packing and shipping, advertising and selling and ecological use of earthworms. The book contains some line drawings and some black and white photos.

Australian back to basics: Worm Farm Management – Eric Wilson – Pennon Publishing (AUS) 2002 ISBN 1877029130 – mainly covers large scale operations rather than backyard stuff but interesting nevertheless. It covers setting up a commercial worm farm, worm biology, bedding systems for worms, breeding management systems, managing, feeding and watering your worms. Also covered are harvesting, packaging and transporting worms, how to harvest and market worm castings, worm behaviours and problems and pests. The book has some black and white photos, a few line drawings and a centre section of colour photos.

Worms Garden For You – Allan Windust – Allscape (AUS) 1997 ISBN 0 646 34280 0 –This book is not too technical but with lots of diagrams, black and white photos and a central section of colour photos. Chapter one is an introduction covering how worms support your gardening efforts, chapter two covers worm anatomy and physiology, Chapter three covers the differences between earth worms and compost worms. Chapter 4 covers worms and making good compost, Chapter 5 covers different types of worm farms and their management, chapter 6 covers how worms react to various soil

types and keeping them happy. Chapter seven provides comments and hints from existing worm farmers.

Earthworms Unlimited – Amy Brown – Kangaroo Press (AUS) 1994 ISBN 0 86417 631 7 – The author describes this as a booklet, it is only 80 pages long, cover to cover. The book is written in the format of one to two pages per subject. It covers getting started with worms and planning the project, possible markets for worms, anatomy and lifecycle of worms, worm accommodation for backyard breeders, bedding mixtures and what to feed worms. Also covered is introducing worms to beds, setting up propagation boxes and obtaining worm capsules. The rest of the book covers harvesting and storing worms, packing the worms, worm enemies and suggestions for marketing your worms. The book has a few line drawings.

Earthworms in Australia – David Murphy – Hyland House Publishing (AUS) 1993 ISBN 978 1 875657 09 6 – The book starts out with four forewords by people I have never heard of. The book moves on and covers what earthworms do for soil fertility, the anatomy of the earthworm, breeding earthworms including species, breeding habits and growth rates. Starting a worm farm is covered including food, beds and caring for worms, worms for profit including waterless toilets, sewage treatment and heavy metal treatment. Growing paking and seeling worms for fishermen is covered as is growing worms in larger amounts, growing for wormcastings including harvesting and packaging, and worm systems for use on farms. The book has a couple of B&W photos, some line drawings and a centre section of colour photos.

Worm Farming Made Simple – Alan Windust – Allscape Publications (AUS) 1997 ISBN 978 0 646 32664 3 – This book is set out in a similar format to ‘worms garden for you’ above, by the same author and focuses on commercial, rather than backyard, worm farming. There are 12 chapters. Chapter 1 is an introduction to worm farming for profit, C2 discusses rules for worm farming success, C3 covers suggestions for worm products and ‘services’ that could be provided, C4 covers worm biology, C5 covers the issues associated with setting up and managing commercial worm systems. C6 covers worm marketing ideas, C7 covers bait worms, C8 covers waste reduction using worms, C9

installing school worm farms and teaching about worms, C10 covers the future outlook for the industry, C11 covers getting started and C12 covers sourcing more information. There are lots of colour and B&W photos.

Worms Downunder Downunder – Alan Windust – Alscape Publications (AUS) 1994 ISBN 978 0 646 31072 0 – This is a larger A4 format paperback, also focused on commercial worm enterprises. Chapter 1 covers why worms are worth farming and how to use the book. Chapter 2 covers worm anatomy, physiology and lifecycle, chapter 3 covers setting up and running various commercial worm systems from site and construction through to harvesting packaging and marketing. Chapter 4 (very short) is on how worms improve soil health, Chapter 5 covers the use of worms in farmland including practices to encourage worms. Chapter 6 (also short) covers garden practices to encourage earthworms, Chapter 7 covers how to set up a worm farming operation in a school Chapter 8 provides examples around Aus & N of people who are running various worm operations and chapter 9 (1 page) talks about potential income opportunities with worms. The book has lots of diagrams and line drawings with a few B&W and colour photos.

Let and Earthworm Be Your Garbage Man – Home, Farm and Garden Research Inc. (US) 1954 ISBN 0 914116 11 8 – This is a small paperback, only 64 pages cover to cover. It is a report about (at that time) a new method of disposing of organic waste. The process in a nutshell is to dig a hole, line the sides with Besser blocks, then toss in the organic waste and cover with hessian bags. The rest of the book talks about how to use the compost from the worm farms, worm species, the effect worms have on the soil and encouraging worm population growth. The book also talks about how to find and grow worms for compost and bail, as well as creating a business based around worms. Lots of black and white photos.

7.4 Books about Chooks

Chicken Tractor – Andy Lee and Patricia Foreman – Good Earth Publications (US) 2000 ISBN 0 9624648 6 4 – While not particularly designed towards the backyard market, it

contains lots of good information of various styles of chook tractor and how they are used. Definitely organic/ Permaculture base. Chapter one covers what a chook tractor is, and chapter two, why you need one. Chapter covers the various types of chook tractor systems and how they are used, including the Polyface Farm model. Chapter four covers making strawbale chook house. Chapter five covers soil building with a chook tractor and why they are better than rotary hoeing, chapter six is a short section on keeping chooks in the tractor including light, health, roosts and perches. Chapter seven covers marketing and making money from your produce and chapter eight covers DIY chook tractors. Later chapters cover chook processing, selecting chooks for your tractor, raising chicks, predators, feeding chooks including organics and chook health and disease. The book has a number of line drawings.

Chicken DIY – Daniel Johnson & Samantha Johnson – Fox Chapel Publishing (US) 2017 ISBN 978 1 62008 230 0 – This book starts out with introductory sections on why bother with DIY, tools and skills required and a look at the history of chook keeping. The rest of the book provides details for twenty, chook related DIY projects. The details for each project includes an introductory discussion, a materials list give the timber etc, parts required and tools needed followed by a step-by-step how to including a photograph of each step. Projects include a chook tractor, quarantine habitat, collapsible chook run, various nest boxes, feeder & waterer, incubator, roost, dropping board, brooder wading pool and lots more. The book has lots of colour photos.

Backyard Chickens: Guide to Coops and Tractors – David Thiel (Ed.) – Betterway Home Books (US) 2011 ISBN 978 1 4403 1696 8 – There is a short and VERY basic section on chicken raising but this is followed by a much longer section (covering the greater part of the book) on construction techniques. This section also provides plans and construction details for 13 stationary chicken houses and 3 tractors. There are line drawing plans for each type of accommodation as well as lots of colour photos showing the stages of construction. There is a resources page at the back, but this is only applicable to the US.

Reinventing the Chicken Coop – Kevin McElroy & Matthew Wolpe – Storey Publishing (US) 2012 ISBN 978 1 60342 980 1 – There is a small section at the front of the book covering the essentials which need to be in every chook house and the basics covering mesh, roofing, construction materials, locks and latches as well as some construction techniques. Each design provides a comprehensive materials list and step by step construction instructions including both line drawings and colour photographs. Most of the designs are simple and easy to build and include both stationary coops and tractors.

Appendix 1 – Soil Test Results Sheet

Soil Test Results Sheet

Date Sampled: ____________ Address: ____ Sampler: __________________

No	Location	Depth	Vegetation	Physical Tests			Chemical Tests				Biological Tests		Comments
				texture (Bottle)	texture (Feel)	Organic matter	pH	N	P	K	Earthworms	Soil Resp.	

Appendix 2 – Companion Planting Plant List

Good Companions

Aromatic Plants (pest confusers/repellers)

anise, basil, bay leaf, brown boronia, cardamom, catmint (nepeta), cinnamon wattle, coriander, curry bush, fennel, frangipani, garlic, ginger, honeysuckle, jasmine, lavender, lemongrass, lemon verbena, lemon scented myrtle, marigold, mint, murraya (curry leaf tree), mustard, pennyroyal, pepper, peppermint (artemesia), rosemary, wormwood, thyme, turmeric

Nitrogen fixers

Acacias, beans, (dwarf, climbing, field, dried), birds trefoil, clover, jicama, lentils, lucerne (alfalfa), lupins, medics, peas (dwarf, climbing, field, dried), peanuts, vetch, wild indigo, wisteria

Dynamic accumulators

Borage, bracken, buckwheat, coltsfoot, comfrey, dandelion, dock, fennel, flax, horsetails, kelp, fathen, meadowsweet, mullein, mustard, nettles, parsley, pigweed (purslane), plantain (ribwort and major), salad burnet, shepherd's purse, sorrel, sow thistle, spurge, tansy, watercress, yarrow.

Green Manure plants

Some nitrogen fixers as listed above, linseed, lupins, mustard, oats, canola, buckwheat, fenugreek, millet, brassicas, wheat, barley, rye.

Native bird attracting plants

Grevillea, banksia, melaleuca, correa, red hot poker, hardenbergia, callistemon, Chinese star jasmine, native indigo, queen Anne's lace, fennel (when flowering), lillypillies, salvias.

Plants to Choke Out the Weeds

Belladonna lilies, dahlias, comfrey lemongrass, garlic chives, marigolds,

Bad Companions

Heavy Feeders (vegetables)

Asparagus, broccoli, Brussels sprouts, cabbage, corn, cucumber, cauliflower, celery/celeriac, kohlrabi, capsicums (large-fruited), spinach, tomato, turnips, zucchini

Other resource competition plants

Roses, pittosporum, eucalypts, large trees, casuarinas, cypress, passionfruit, agapanthus, most annual flowers,

Plants exhibiting allelopathy

Black walnut, sunflower, corn (when young), onions. Marigolds (esp when decomposing) annual rye (grain), daffodils, bracken, peas, rice, sorghum, pines, broccoli, cabbage