Natural Fertilizers And Their Use In Agriculture

A natural fertilizer is a product which originates from the environment naturally or is derived from products which originate from the environment whereas a mineral fertilizer (or chemical fertilizer) is made by chemical processes in a factory. The term natural fertilizers, as generally used, also includes products that originate from the environment naturally but are further processed in a factory, such as fish emulsion or liquid seaweed. The term natural fertilizer is normally reserved for products which are renewable. We have deliberately excluded mined product such as rock phosphate and potassium nitrate from this list because although they occur naturally the resource is finite and non-renewable.

Natural fertilizers are not the same as organic fertilizers. The term organic fertilizers have several different meanings and it is often difficult to decide what is meant by the term "organic fertilizer" in any particular situation. The scientific meaning of organic means a substance which contains carbon in the molecule.

There is an Australian Standard for Organic farming and this defines both organic produce and allowable inputs into organic production but does not depend on organic certification bodies. The Organic certifying bodies also have their own set of criteria for "allowable inputs for organic farming" a few based on science but others on tradition with little or no scientific basis.

Traditionally natural fertilizers have been more expensive than mineral fertilizers however in the last decade or so mineral fertilizers have become much more expensive and natural fertilizers have hardly risen in price.

It has also been accepted by government authorities in the last decade or so that inappropriate use of mineral fertilizers severely damages the soil, a fact that scientists have warned about for several decades.

Furthermore, conventional farmers are now realizing that the microbial activity, usually enhanced by natural fertilizers and reduced by mineral fertilizers, is of paramount importance in crop protection.

Common nitrogenous chemical fertilizers, particularly urea undergo a series of reactions in the soil which lead to the emission of the greenhouse gases, carbon dioxide and nitrous oxide. Nitrous oxide absorbs radiation and is generally thought to be about 300 times more potent than carbon dioxide as a greenhouse gas.

Much of the granular urea applied never gets into the plant and is decomposed to carbon dioxide and ammonia. Some of the ammonia is released into the atmosphere and some is oxidized to nitrous oxide which in turn is lost to the atmosphere. Each tonne of urea that is wasted leads to the production of greenhouse gases with the same effect as several tonnes of carbon dioxide. This represents a significant economic loss and a significant contribution to greenhouse gas emissions.

The major natural fertilizers are:

Animal manures.

In Australia chicken manure is probably the most widely used. Animal manures are usually composted but, generally not further processed and the quality is quite variable. Animal manures are a good source of carbon and nitrogen, with small amounts of phosphorus and potassium. Chicken manure has a reasonable level of calcium. Typical application rates are in the tonne per acre range. The cost is usually dominated by the freight contribution. Dairy effluent is another important natural fertilizer which is usually used on the farm it is produced on. Animal manures increase the bacterial activity however they also generally reduce the fungal activity. Their use should be supplemented by application of seaweed or fish emulsion to increase fungi levels.

Stubble and crop trash.
Crop trash is the general term used to describe the residue of plant material which is not part of the saleable crop. There are specific terms for the trash of some types of crop eg grape marc is consisted of skins, stems and seeds and the term stubble is reserved for cereal crop trash which is left attached to the roots. Crop trash can be an important contributor to soil fertility particularly nitrogen levels. Care is needed to get the maximum benefit from this source. The aim should be to get the breakdown products into the soil without losing too much nitrogen to the air or greatly disturbing the soil profile. The usual practice is to disc the stubble so that it is contact with the moist soil and apply a small amount of a mineral nitrogenous fertilizer, such as urea or calcium nitrate or a natural fertilizer such as fish hydrolysate. Fish hydrolysate supplies small amounts of nitrogen but, probably more importantly supplies particular amino acids which increase soil microbial activity.

Abattoir and butchers waste.
This is usually sold as blood and bone. It is a vile smelling product containing valuable amounts of carbon, nitrogen, phosphorus and calcium. Its use is restricted on some crops and pasture because of possible links to "mad cow" disease. Typical application rates are between 10 and 50 kg per hectare.

Fish hydrolysate (fish emulsion).
There are large amounts, at least 8,000,000 L of fish hydrolysate produced in Australia and the quantity is rising significantly each year. (NOTE: here we use the terms emulsion and hydrolysate with their scientific meaning). Often there is a distinction made between fish hydrolysate and fish emulsion. This is irrelevant for Australia because all hydrolysates sold in Australia are also emulsions.
The quality of fish hydrolysate and blend of amino acids from fish waste depends on the method by which the fish protein and fat are broken down (digested). There are a number of ways of breaking down the protein and/or fat. The most common method is to use an enzyme which is added to the fish waste. These enzymes are produced by a number of methods, usually with the aid of bacteria. Another method uses the enzyme found naturally in the fish gut. Often the fats are not broken down to any great extent but are emulsified in the product.
Fish hydrolysates are high in carbon but have relatively small amounts of nitrogen, phosphorus and calcium and small amounts of potassium, sulfur and trace elements. In most processes some phosphorus is added. Fish hydrolysate is a good source of peptides and/or amino acids. It provides a good source of nutrition for microbes, both bacteria and particularly fungi. Typical application rates are 10 or so litres per hectare.

Fish hydrolysate can be used in a number of situations. It can be used

- To increase the microbial activity in the soil, particularly the growth of fungi which is of paramount importance. Australian soils used for crops or pasture are usually fungi deficient even if there is sufficient bacteria. The increase in microbial activity increases soil health and the utilization of nutrients locked up in the soil.
- To help break down stubble or crop trash.
- To feed actinomycetes (actinobacteria) which provide plants with plant growth regulators. Scientists have noted for many years that the level of macronutrients (NPKS and Ca) and micronutrient levels in fish hydrolysate only partly account for the observed beneficial effects. It now appears that the observed benefits are due predominately to the unique mix of amino acids (and possibly other compounds easily utilized by bacteria and fungi) that fish hydrolysate contains. These compounds are absorbed by a group of bacteria including a major group known as actinomycetes (actinobacteria). These bacteria in the rhizosphere feed on the amino acids and produce a number of plant growth regulators, PGRs which in turn are taken up by plants and significantly increase their growth.

- To provide small amounts of macro (NPKCaS) and micro nutrients. Although the amounts are small if the level of any nutrient is grossly deficient the effect can be very significant. Fish hydrolysates produced from tuna waste are usually a good source of selenium.
- Fish hydrolysate is often mixed with liquid seaweed and/or molasses. The fish/seaweed/molasses blend has proved to be cost effective on a number of dairy farms. Fish, on its own will not provide complete nutritional requirements for a dairy farm soil so there needs to be some additional appropriate nutrients either from small amounts of mineral fertilizers or as a result of feed brought in from other parts of the farm or from off farm . Using a seaweed/fish/molasses blend will result in a dramatic increase in microbial activity and living organic material, increases in the water holding capacity of the soil and increases in the utilization of locked up nutrients.

Molasses.

This is a by product from sugar refining and is high in carbohydrates including sugars and trace elements. The benefits of molasses as a growth promotant do not seem to have been extensively investigated in a scientifically rigorous manner. However, circumstantial evidence suggests that molasses is effective on a range of crops and pasture. The use of a combination of seaweed, fish and molasses appears to give excellent growth in pasture and increased yields in potatoes. Typical application rates are 10 or so litres per hectare.

Liquid seaweed.

Liquid seaweed or liquid kelp is the name given to seaweed which has been treated to produce a liquid. By far the most common treatment involves use of potassium hydroxide or potassium carbonate. Liquid seaweeds are normally digests but traditionally called extracts. Liquid seaweed contains small amounts of potassium but the benefits are mainly due to the plant growth regulators (PGR) it contains. The PGRs include auxins, betaines and minute amounts of cytokinins. The successful processing of seaweed into a liquid suitable for foliar application is a complicated process and many products made by simpler processes are thick and gluggy are only suitable for very coarse spray application. Small amounts of liquid seaweed are needed, typically a few litres per hectare.

Considerably more has been spent in recent years on research into seaweed and natural fertilizers worldwide than on conventional mineral fertilizers with significant spinoffs relevant to agriculture.

Many beneficial effects have been observed from the use of liquid seaweed on plants. All of those listed below are explainable - at least in part - by the known effects of one or more of the plant growth regulators present.

The list of scientifically documented observed effects includes:

(a) increase in nutrient uptake
(b) increase in yield
(c) increase in shelf life of fruit and cut flowers
(d) increase in frost tolerance
(e) increase in high temperature tolerance
(f) decrease in water stress, due both to drought and salinity
(g) increase in chlorophyll production
(h) increase in resistance to fungal attack
(i) increase in resistance to sucking insect attack
(j) increase in rachis stretch (grapes)
(k) increase in fruit set
(l) increase in effectiveness of synthetic fungicides
(m) more rapid germination.
(n) delay in senescence (senescence is the dying off of the plant after it has completed its life cycle)

This list starts with an increase in efficiency of nutrients uptake leading to flow on effects arising from a healthy plant. Auxins stimulate root development as well as root hair development and this may partly explain the increased fertiliser uptake. However, this is not the complete explanation and increased root development may not even be the principal effect. Liquid seaweed extracts have been shown to increase the amount of root exudates, material sent out into the root zone by the plant. Root exudates is an important factor in nutrient uptake as it feeds soil microbes which make soil nutrients available to the plants. Both auxins and betaines appear to have a part in causing this increase in root exudate.

The increase in frost, drought and saline tolerance is believed to be due partly to the betaines in the liquid seaweed. However, scientists still do not have a complete explanation. Betaines are known to play a key role in helping plants continue to function under cold, heat and water stress. Plant species that tend to survive frosts tend to be high in betaines. Similarly, plants that survive in arid and saline conditions also tend to be high in betaines. Betaines are known to accumulate in the cytoplasm of the cell and they minimise the effect of the environment on the reactions which occur in the cytoplasm.
The observed increase in resistance to fungal attack and to sucking insect attack is usually attributed to the phenolics, which include the sub group referred to as polyphenols (or phlorotannins) in the liquid seaweed. Some disease-resistant plants restrict the spread of fungal pathogens and subsequent damage to cells to a small area around the point of initial entry. It is thought that some phenolics are basically compounds that cause this localisation of the damage.
The observed increase in fruit set, and increase in rachis stretch (the elongation of the distance between neighbouring grapes in the same bunch) in grapes is probably due principally to the auxins, but again there is almost certainly an interaction with other plant growth regulators. To obtain an increase in fruit set and optimum rachis stretch the timing of the application is crucial.
The observed increase in post harvest shelf of fruit and vegetables is almost certainly due partly to cytokinins and possibly partly due to betaines. Increased post harvest shelf life of leafy vegetables can be linked to delayed leaf senescence, a well-established effect of cytokinins. This in turn could contribute to the observed increases in yield of some crops by delaying leaf senescence (dying off) and thus extending the growth period. Potatoes are a prime example of a crop where a delay in senescence can give rise to increased yields. Delay in senescence of cut flowers is also important and liquid seaweed application 3 or 4 days before cutting can significantly extend vase life.

Humate and fulvates.
These are usually made from oxidized brown coal or peat. Humates and fluvates differ in the size of the component molecules. Typical fluvate molecules are much smaller than humate molecules. Both humates and fulvates contain small amounts potassium and trace elements. Fulvates can be applied as a foliar feed but humates with the larger molecules cannot easily be absorbed through the foliage. These "natural" fertilizers are potential ly extremely useful but their price, arising from the difficult production process, is a major draw back to their widespread use except in high value crops. Humate and fulvate compounds have the ability to hold nutrients in light sandy soils and hold them in a form which enables them to be absorbed by plants. Humates are soluble in alkaline solutions but not acidic solutions whereas fulvates are soluble in both alkaline and acidic solutions. Small amounts are needed, typically about 5-10 litres per hectare.

Compost and Compost teas.
These are usually made from the microbial break down of plant material. Compost is the name usually given to the semi-solid material whereas compost teas are liquids or suspensions. Both can be good sources of microbes but the quality of the product varies from excellent to virtually useless. To make good composts or compost teas it is important to understand the processes involved and carefully control them.

Usually composts are used at tonnes to the hectare rates whereas compost teas are often used at much smaller application rates. The procedure to make compost teas can be varied to give end use products which are quite different in their properties. Compost teas which have some fungicial activity are potentially extremely useful. Although composts and compost teas have been used for decades by home gardeners their widespread use in farming more recent. Use of this type of natural fertilizer is expanding rapidly.

Guano.
This is essentially bird droppings. The product contains moderate levels of nitrogen, phosphorus and calcium. It is attractive for use in the home garden by its use in agriculture is limited by cost.

Biochar.
Biochar is made by heating carbon containing material in a limited supply of air. The end product is very dependent on the starting material, the temperature reached and the amount of air available. Biochar is essentially a blend of carbon and nutrients. Many of the claims for biochar are due to the rapidly exhausted nutrients it contains rather than the long term stable inert carbon portion. If the material used to make biochar can be easily composted then this would be a better use of the carbon and nutrients as far as soil fertility is concerned. The main value of biochar is as a method of storing inert carbon in the soil. However, the form of the carbon stored is not particularly valuable as a source of what is generally referred to as "soil carbon". The carbon from biochar is inert and although it may well absorb some nutrients which could be taken up by plants this is insignificant as far as increased fertility is concerned. The carbon from biochar is likely to remain locked up for hundreds of years.

Green manures.
This is the name given to crops , usually legumes, which are grown and then ploughed back into the soil. The crops add some organic material (using the scientific meaning of the word) to the soil together with some nutrients. If legumes are used the added nitrogen can be equivalent to adding 100 kg/ha of the a mineral fertilizer rich in nitrogen, such as urea. The use of green manures removes the land from saleable crop production for several months and this has led to a reduction in the acreage used for green manure production over the last fifty years. However, as farmers and agronomists have realized the importance of organic material in the soil the practice of using green manures has seen some revival in some niche situations. The net benefit of using green manures depends on numerous factors, such as the nature of the soil and the overall cropping plan. In low carbon sandy soils the increase in soil organic matter can be of considerable benefit in reducing the water and fertilizer needed to grow a crop following the incorporation of a green manure crop.

Food process waste.
In addition to fish waste, molasses, grape marc and abattoir waste there are numerous other niche food processing waste which are being used as fertilizers. The benefits of using these depends on a wide range of factors, in particular, the timing and amount of waste available and the nutrient content. The grower hoping to use these wastes needs to devote considerable effort to investigating the real cost and the side effects of their use and evaluating the benefits. Currently this group includes by products from yeast production, off specification batches of confectionery passed use-by date material and leafy material from tinned or frozen vegetable production.

Worm "juice' or worm castings.
These are respectively the mucous like material secreted by worms as they pass through the soil and material produced by the worm from food and soil. The household "Worm Farm" turns kitchen waste into a liquid containing significant amounts of soil nutrients. Commercial worm farms rely on literally millions of worms to do the same thing with straw, animal manure, other plant material and often added seaweed, fish waste, rock phosphate and numerous other components aimed at increasing the nutrient value in the worm juice. The normal practice is to make the worm food into long rows (windrows) to which new material is added periodically to the windrow surface. The worms are mainly active in a surface layer of typically 200 mm depth. With changes in moisture content and temperature the worms either go more into the inside of the windrow or retreat to nearer the surface.The life of the rows is often several years and they may be several metres high before being decommissioned. The worm juice oozes out of the bottom of the heap and is collected (and often recirculated back over the heap). The value of worm juice lies in the microbes and small amounts of nutrients it contains. Worm casting are the material left in the heap and this also contains microbes and small amounts of nutrients. Relatively little scientific work has been undertaken on such products although it appears that there are big differences in the efficiency of products on the market.

Conclusion and future predictions.
The natural fertilizer industry in Australia is small and has numerous players. It is highly fragmented and has suffered in the past from a lack of investment. The situation is likely to continue with marginal improvement, at least for the next few years. However, these comments should be balanced by noting that the world demand for food and fibre is likely to grow at about at least 8% compound in each of the next four decades. The world demand for protein is likely to grow at a greater rate, probably greater than 10% compound in each decade. Australia may well grow at even double that world rate. The cost of fertilizers, particularly those containing phosphate, will increase well above the CPI as world supplies of high grade phosphates are rapidly becoming exhausted. Furthermore the economic benefit from recycling fish and abattoir waste will continue to rise as landfill becomes more expensive. The dramatic increase in world demand for protein will ensure that animal manures, particularly chicken manure will remain a cost effective natural fertilizer.
Foliar fertilizers are generally more environmental friendly than granular fertilizers and lead to much less greenhouse gas emissions. For this reason it is expected that liquid seaweeds and fish hydrolysates will continue to maintain their position in the natural fertilizer market. In Australia, part of the increase in fertilizer costs will be offset by the adoption of foliar (chemical) fertilizers (as has already occurred to a significant extent in the Northern hemisphere). Combinations of chemical and natural foliar fertilizers are now becoming more commonplace and are likely to gain market share because of environmental concerns.
Many of the recent advances in the understanding of the chemistry and biology of seaweed, fish and their uses has not filtered from the research into products. Once this occurs it will give added momentum to the growth of the natural fertilizer industry.
Considering all of these factors it would be expected that natural fertilizer product will need to increase significantly during the next few decades. It does not appear that, in general, raw material supply will be a limiting factor, possibly with the exception of some types of animal manure. It is expected that as fertilizers become relatively more expensive all the above natural fertilizers will become more popular.