Biological Fertilisers Workshop

Biofertilisers can be derived from microorganisms (and in some cases are actually live microbial inoculants), algae (seaweed) or higher plants. This workshop will cover much of these forms and discuss the potential modes of action and the best way to utilize them.
Humic and fulvic acid products are also increasingly available. These are also biologically derived albeit from eons ago when coal was formed. They have a variety of uses that range from significant cation exchange effects in the soil through to stimulatory and chelation effects to improve plant growth and nutrient uptake. These are not covered in the workshop but there does seem to be beneficial effects from their use. Humic acids may be useful if applied in bulk to improve nutrient holding capacity of soils or spayed on as a plant stimulant, they can also be mixed with liquid preparations of nitrogen fertiliser to perhaps provide a slower release of nitrogen. Fulvic acids are smaller in size and soluble, they have a significant effect on improving nutrient uptake and decomposition of pesticide residues and stimulating plant growth.

Some definitions of biological fertilizers include chemical fertilizers whose main action is to stimulate soil biological activity. These are not covered in this workshop but they include: Fine limeflour (e.g. 1 to 80 micron, applied @ 10 to 200 kg/ha) in suspension or by careful spreading (avoiding too much loss of the small particles) to stimulate beneficial soil microbial activity. And liquid fertilisers, which can be used strategically to apply some trace elements that are not taken up efficiently from some soils, and apply major elements at key limiting times for fast uptake and effect. In many cases the liquid fertiliser's effect can be largely due to a biological stimulant present in the product which along with some of the chemical nutrient components are able to improve plant growth and quality.

Mode of Action of Biofertilisers

Biofertilisers act to stimulate plant growth and the plant immune systems. They help overcome periods of stress for the plant and help the plant achieve its potential. They enable a more efficient utilisation of nutrients. It is important to stress that the amount of mineral nutrients in biofertilisers (especially liquid ones) may be to low to be the sole major element source for a long term sustainable nutrient budget.

Biofertilisers usually contain a range of growth promotion factors with some of the main ones being forms of cytokinin (a microbial and plant hormone responsible for promoting cell division and growth) including betaines. Plants produce their own cytokinin though this production may be limited at times of stress or simply below optimum, and plants can respond positively to the application of cytokinin alone. The theory with biofertilisers is to provide a range of growth promotion factors and compounds that also increase the uptake of nutrients e.g. through stimulation of fine feeder roots and general root production and/or an increase in cell permeability.

The claims of benefits usually include some of…

- increased plant growth
- higher Brix levels (more "energy" in the plant)
- better plant nutritional quality
- increased ability for nutrient uptake
- increased fine feeder root formation
- particular benefit for legumes (e.g. in pasture)
- increased nodulation in legumes
- increased chlorophyll content (for photosynthesis)
- lower free nitrogen content in plant tissue (higher quality)
- reduced pest and disease pressure

Most of these aspects lend themselves to testing and in the case of commercial products, manufacturers may or may not be able to provide research data of their own or from independent testing. It is possible to set up simple trials to go some way towards establishing whether the product is worthwhile in a particular system.

Many growers will make their own products which saves money at the expense of taking time and energy. Such "home-made" products might utilize resources that are on-farm, nearby or relatively free.

Some of the techniques used by commercial companies might make a higher value product that home-made products (this could be tested) and the extra financial outlay may be worthwhile – a case by case pragmatic decision. This does not, however, sit well with the idealistic aim of reducing outside commercial inputs.

All of the above benefits have some basis in scientific literature but results from biofertilisers are characteristically variable perhaps due to product quality and probably also due to environmental fluctuations and the vagaries of not understanding the actual modes of action.

Biofertiliser Use

Time of Day: Best applied on overcast or drizzly days or in the early morning or late afternoon to avoid the excessive death of any live microbes and to improve the amount of foliar uptake of the biofertiliser.

Timing with Crop: Best applied at key growth stages such as germination, emergence, stem elongation flowering and fruit formation.

Time of Year: Least likelihood of effectiveness at times when growth is limited by climatic conditions e.g. too cold or too dry. On the other hand some biofertilisers may be useful in reducing frost damage and/or helping to overcome the stresses (and low plant hormone production) of dry conditions.

Method of Application: Spraying over plants is generally better than applying just to the soil as there can be more direct benefit to the crop plants. A finer spray is generally better.

Mixing: Most liquid products should be diluted at least 1 to ten to help avoid damage to crop plant tissue. Live microbial products should not be mixed with other materials (e.g. copper, lime sulphur, high concentrations of nutrient etc) that will inactivate or kill the microbes (if an inoculant effect is desired).

Sources of Biofertilisers

Types of Microorganisms

Some products contain single species (often selected strains of microorganisms and others can contain a wide range to gain potentially wider and synergistic effects. Some products may simply contain extracts of microorganisms that include growth promotion factors.

Bacteria

Many different types of bacteria are used as either live inoculum or providers of biofertiliser extracts. Fluorescent pseudomonads have been extensively researched for their growth promotion effects and some other types are detailed below.

Cyanobacteria

These are primitive bacteria capable of photosynthesizing and producing oxygen. Their benefits in the soil system are many fold and include, provision of oxygen to aid plant root health and nutrient uptakes as well as aiding general soil biological activity through the provision of oxygen, chelating agents (for improving nutrient uptake), growth stimulating factors including hormones and simple proteins), production of sticky polysaccharides for improved soil structure and water holding capacity. Some forms are also capable of nitrogen fixation (free living in the soil or associated with plant roots and nodules. A few forms are capable of solubilising phosphorus from its mineral form making it available to microbes and plants.

Lactic Acid Bacteria

Probably best known for their pivotal fermentative role in yoghurt making, they are also an important part of the manufacture of quality silage. In the soil system they can be beneficial by aiding the fermentative decomposition of organic matter and producing growth promoting substances that benefit many microorganisms and plants. They also produce bacteriocins and other natural toxins that restrict the growth and activity of other soil microorganisms particularly harmful ones.

Actinomycetes

Actinomycetes are a range of hardy bacteria of which many are filamentous (grow in threads). Much of the microbial smell of “good” soil is due to actinomycetes.

Some species of actinomycetes have been used to provide extracts useful as biofertilisers with high levels of growth promoters. These are usually species that do not produce antibiotics.

Purified antibiotics not counted as part of the biological's spectrum because the action is mainly one of antibiosis rather than stimulation. This can lead to antibiotic resistance and causes problems for some forms of beneficial bacteria. The actinomycetes can produce ionophore antibiotics which interestingly increase the uptake of nutrients including cations (to the detriment of susceptible organisms). In a biofertiliser, the presence of or stimulation of organisms that antagonize harmful microorganisms may be one of the modes of action. This differs from the use of a specific purified antibiotic in that there is arrange of modes of action, many of which are stimulatory rather than antagonistic and the lack of purification reduces the likelihood of resistance developing.

Fungi

Two of the main types of fungi used in biofertiliser production are mycorrhizal and yeast. Other types of fungi e.g. *Aspergillus oryzae* and *A. niger* may also be used, often for their extracts which contain growth promoters. Nematode predating fungi may are available in some countries for potentially reducing nematode problems.

Mycorrhizal Fungi

Almost all crop plants are capable of a special beneficial relationship with fungi partly inhabiting (“infecting”) the plant roots and partly growing out into the soil. The mycorrhizal fungi increase nutrient uptake for the plant (especially phosphorus which is not picked up efficiently by many crop plant roots without mycorrhizal “infection”) reduce the susceptibility of the plant to root disease.

There are some products available that provide a range of mycorrhizae suitable for most crop plants. In most cases the right organisms will already be present in the soil and may just need extra stimulation and the provision of the right soil conditions (including not too much soluble phosphorus fertiliser use) to achieve good levels of root “infection”.

Yeasts

Most yeasts are very fast growing and many are useful for providing good levels of growth promoters for use in biofertilisers. Low alcohol strains of beer yeast (*Saccharomyces cerevisiae*) are sometimes used in the manufacture of biofertilisers and are often included in animal probiotics.

Trichoderma *spp.*

Selected strains of various *Trichoderma* spp. are very efficient at dominating soil and plant habitats and controlling plant disease. They have also been shown to stimulate plant growth including root production. Several are commercially available in New Zealand.

Algae (seaweed)

Many people make their own seaweed brews from beach collected seaweed. In commercial preparations, there is often an emphasis put on live harvesting (e.g. using deep sea divers) to gather highly active material (higher levels of growth promoters).

Plants

One of the principles of selecting plants as biofertilisers is to try fast growing plants. Although seaweed is generally much faster growing, successful commercialized biofertilisers have been made from…

Giant Knotweed (*Reynoutria sachalinensis*)

A relative of dock, commercial preparations are available in Europe and North America. Used to induce resistance to fungal diseases (including powdery mildew and botrytis). Found to increase plant growth and yield, provide more intense flower colour in flower crops and increase chlorophyll content (photosynthesis capacity) of crop leaves. Giant knotweed is from the far north of Japan naturalized as a large weed in areas of the South Island West Coast. A water extract can be made with either fresh leaves or dried crushed leaves.

Yucca (*Yucca schidengo*)

This Central American plant is commonly used to reduce odours from in dung and other waste material. It has also been suggested to aid soil biological activity through provision of a surfactant action protection of soil microorganisms from water stress. Sometimes used as an additive to other materials in a biofertiliser product. Grows naturally in Central America but with the growth of use of this plant in health and agricultural products, the plant has suffered over harvesting and is now largely grown in plantations. In New Zealand Yucca material can be purchased from importers.

River Hemp (*Sesbania cannabina*)

River hemp is an Australian member of the pea family and is used for biomass production and also due to high levels of growth promoter compounds is used as a biofertiliser.

Home Remedies are also made from…

Comfrey (*Symphytum *spp.)

Comfrey is commonly used to make comfrey liquid manure to provide small balanced levels of nutrients and levels of microorganisms. Leaves are left to ferment in water for a matter of weeks. Usually the range of microorganisms depends on those present on the leaves to start with and the conditions (rather anaerobic) in the container.

Willow (*Salix *spp.)

This fast growing tree genus is used to make willow water (leaves soaked in water) which can be used as a stimulant for plant cuttings.

Dock (*Rumex *spp.)

A water extract of dock leaves has been shown to be effective against powdery mildew and due to its relatedness with giant knotweed, may also be useful as a stimulant of plant growth.

Stinging Nettle

Water extract of stinging nettle is used to simulate strong plant growth sometimes with a belief that the silica contained in nettle is useful in strengthening the plant cells against disease attack.

Potential Contradictions in Microbial Inoculant Theory

Anaerobic is Bad?: Some of the writings on biofertilisers and microbial inoculants seem contradictory. Many describe anaerobic as bad and aerobic as good. This is a simplification which though largely true, neglects the benefits of many anaerobic organisms and also might overlook the fact that there will always be copious anaerobic pockets in the soil which are best being filled with beneficial anaerobic organisms rather than harmful or wasteful ones.

Microbial Inoculants Will Suffer in Soil Conditions: But there is a strong element of truth that conditions should be improved to aid beneficial organisms. Indeed if some of the action is actually a stimulatory one then it is achieving just that. Many of the natural processes of beneficial organisms will aid the provision of better conditions for beneficial organisms. On a large scale it can, for instance, be seen that if earthworm activity is increased by stimulatory means then the earthworm activity will improve soil conditions (including soil structure, soil aeration, soil pH, nutrient availability, microbial activity) yielding a longer lasting effect of the stimulation than may have been initially anticipated.