Microbial Inoculum for Cropping

An Introductory Grower Guide

This project is supported by The Ian Potter Foundation and the Department of Agriculture, Fisheries and Forestry through funding from the Australian Government's National Landcare Program.

Thank you to Stuart McDonald for generously sharing his story and to Chandra Iyer from Green Microbes for his technical assistance with this guide.

Microbial inoculants are living organisms used in agriculture for a specific purpose such as providing nutrients, suppressing disease or for plant growth promotion.

Microbes can provide many benefits for agriculture:

- Nitrogen and carbon fixation
- Unlocking soil phosphorus for plants
- Increasing soil aggregation for better moisture-holding capacity
- Insect and disease control
- Stimulating plant and root growth
- Protecting plants against stress conditions, e.g., salinity, drought
- Increasing plant competition against weeds
- Remediating soil contaminants, e.g., heavy metals.

Microbial inoculant products come in powder, granule, slurry or liquid solution form. Some contain a single organism and others include a mixture of organisms. Unlike chemical fertilisers that contain plant nutrients, microbial inoculants contain beneficial microorganisms that help plants access nutrients from the soil.

Microbial products can be an economical option that provides both soil health benefits and increased plant productivity. It's important to note that inoculants have a temporary effect on the soil, ranging from a few days to a season. They should not be considered as soil health in a bag, but rather as one part of the sustainable farming practices required to build soil health, and are helpful when transitioning to these practices.

Grower Insights
Stuart McDonald, Canowindra NSW

'Mycorrhizal fungi is a great element for overall soil health. If you are using any microbial amendment on your soil, you are in it for a long payback period. You are not going to apply it and see things change straight away.

Inoculums are only a small part of the process of changing the microbial composition of your soil. There are plenty of other factors that are going to be bigger influencers on your microbial population, including your other agronomic practices and how you are managing your paddocks. For example, whether you are keeping residue on the surface, whether you are cultivating it, what your crop rotation is and whether you are using significant herbicides, these all potentially impact it.

We are trying to improve the basics around protecting our soil - retaining all residue, and utilising livestock to try and cycle that residue.

Using microbial inoculants is a long-term approach to building organic matter and resilience into our soils, which for me means 5- 10 years - although I've heard 3-6 years being bandied around.

It all depends on the years you have, whether you have a couple of drought years or a couple of good years. And this is of course only approaching one angle of it, as we still have historical soil limitations in pH and compaction zones that we are addressing."

Stuart McDonald

AGRICULTURAL

Microbes 101

Microbes for agriculture fall into four groups: bio-fertiliser, bio-fungicide, bio-pesticide or plant growth-promoting bacteria.

There is a wide range of microbial inoculum on the market for growers to consider. Over the next two pages, we take a look at some of the bio-fertiliser and plant growth-promoting microbes used in inoculum.

Rhizobia - nitrogen-fixing soil bacteria

One of the most successful and ubiquitous microbial inoculum, that most growers would be familiar with, is rhizobium bacteria used for legume crops.

These products set an industry standard against which all other agricultural inoculum can be measured. Rhizobium products are distributed under strict quality assurance programs to ensure efficacy. The specific strain or 'group' of rhizobium must be selected for each different legume crop.

Free-living nitrogen-fixing bacteria (NFB)

Free-living nitrogen-fixing bacteria produce plant-available microbial nitrogen via the same biological mechanism as rhizobium, in that they both manufacture the nitrogenase enzyme that allows the nitrogen fixation process to take place.

These NFB, however, are not symbiotic like rhizobium but instead reside in the soil, often at the root-soil interface or sometimes inside the plant itself.

Although they generally do not contribute the same amount of nitrogen that rhizobium is capable of doing, their contribution to plant-available nitrogen can be significant.

Mycorrhizal fungi

Mycorrhizal fungi, also known as Arbuscular Mycorrhizal Fungi (AMF) and Vesicular Arbuscular Mycorrhizal fungi (VAM), are organisms that grow on plant roots.
They form symbiotic relationships with over 90% of the world's terrestrial plants.

In this mutually-beneficial arrangement, the plant swaps carbohydrates with the fungi in return for nutrients that the fungi is more capable of accessing, such as phosphorus, zinc and nitrogen.

The mycorrhizal fungi are able to do this because they are made up of hyphae - long, fine filaments - that branch out to form large networks well beyond the plant's root depletion zone, which can be up to 25cm from the roots.

These hyphal structures wrap around the soil and exude a sticky glycoprotein called glomalin that sticks soil particles together. This process forms soil micro-aggregates that trap carbon in their structure which increases:

- Soil structure
- Water infiltration and holding capacity
- Overall stable soil organic carbon in the soil

Mycorrhizal fungi spores can be applied to seed at planting in order to inoculate the crop with these organisms that are beneficial to the plant and soil function.

AGRICULTURAL

Microbes 101

Carbon fixing fungi

Dark Septate Endophytes (DSE) are another type of beneficial fungi that, like mycorrhizal fungi, help plants access nutrients and cope with drought stress by improving soil structure and aggregation which increases the water infiltration and holding capacity of the soil.

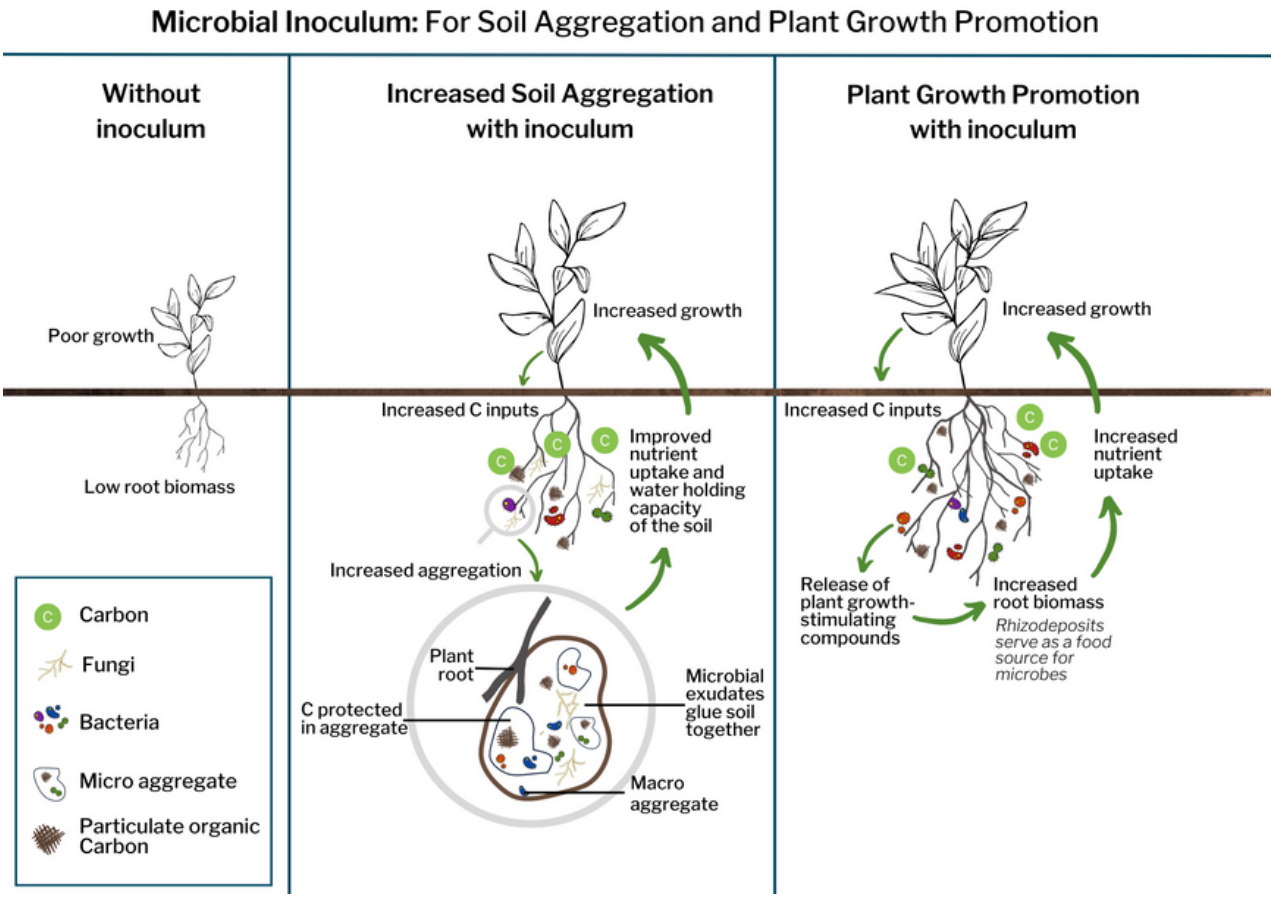
What makes them different though is that they produce dark-pigmented compounds such as melanin in their hyphae. Melanin is a polyaromatic carbon that has been shown to be a more stable form of carbon. As hyphae with melanin proliferate in the soil, the filaments deposit melanin and other carbon-rich substances within soil aggregates where the carbon is protected and can remain for longer periods. As such, these fungi can be an important component towards building a stable soil organic carbon pool in the soil.

Plant growth-promoting bacteria

Certain bacteria that live in the root system with plants that have plant growth-enhancing effects are known as Plant Growth Promoting Rhizobacteria or PGPR.

These organisms exude growth-enhancing compounds such as hormones that increase plant root mass, root branching and root hair density. This, in turn, increases the nutrient and water uptake capacity of the plant.

As the bacteria survive off plant root exudates, both plant and bacteria are in service of one another in a mutually beneficial relationship.



USING

Microbial Inoculum

The following practices are recommended to enhance the benefits provided by microbial inoculants:

- Eliminate pesticides that hinder microbial growth
- Avoid tillage and other soil disturbance
- Avoid over-applying fertilisers or manure
- Enhance plant biodiversity
- Ensure that a crop is growing or has roots in the ground throughout the year

Choosing the right product

The first rule of assessing any microbial product for your farm is to look for and assess scientifically validated trial results.

The second rule is to ensure the product has a Quality Assurance associated with it that shows the organisms are in the concentrations they need to be at the point of application.

The third rule is to use a microbial product that solves the issue you need to solve. It's 'Horses for courses' with microbial products.

Remember- microbial products are living organisms, not inert substances, so being confident that they are alive and well when you use them is critical.

Caring for your microbes

Because microbes are living organisms, they need a little extra care - they can't just be stored in the shed like a bag of urea.

To care for your microbes:

- Store between 4°C-10°C, and do not freeze (different products may have different storage conditions so be sure to read the label)
- Store out of direct sunlight
- Do not store for prolonged periods
- Do not store opened packs of inoculant.

Getting your microbes into the ground

Microbial inoculums are applied via seed treatments, soil applications such as liquid injection or in a furrow spray at planting, or as foliar sprays.

When applying inoculant:

- Do not use an out-of-date product
- Choose the appropriate method of inoculant application
- Apply inoculant at the recommended rate
- For best results, treated seeds should be sown into a moist soil profile immediately
- Treated seeds that haven't been sown within 24 hours must be re-inoculated
- Do not mix inoculants with pesticides, fungicides, fertilisers, trace elements or any other chemicals.

It's important to follow the instructions on the packet. Because there is such a wide range of microbes used to create a variety of microbial products on the market, each product is unique and has particular instructions to ensure you get the maximum benefit of their use.

NATURE'S FREE INPUTS

Building Soil Carbon

Microbial products are unique in that they can grow and replicate in the soil and perform many useful functions towards improving soil carbon sequestration. These include the following:

Soil Aggregation

Many microbes produce a range of sticky exudates that help bind soil particles together that create aggregates - small clumps of soil that are stuck together.

The more 'aggregated' a soil becomes, the better soil structure becomes, in terms of:

- Air-filled porosity
- Water infiltration, drainage and water holding capacity
- Nutrient availability
- Root access.

Carbon is more easily trapped inside soil aggregates where it is rendered more stable or 'recalcitrant', which improves soil carbon levels and further improves soil nutrients and water dynamics in the soil. The old saying "It's the glues and gums that make the crumbs" helps us remember this important function of soil microorganisms.

Plant Growth Promotion

There is a range of microbial products that offer plant growth promotion, such as increased early root vigour by the production of plant growth-stimulating compounds such as hormones.

Nutrient cycling and acquisition

Some microbial inoculums are specialists at releasing and acquiring locked-up nutrients such as phosphorus for the plant.

Certain phosphorus-solubilising bacteria produce the phosphatase enzyme that liberates or unlocks phosphorus for plant use.

Mycorrhizal fungi also produce phosphorus-releasing acids which they pipe from regions unavailable to the plant root back to the plant, in exchange for plant sugars.

Drought resilience

Many soil microbes help to improve soil aggregation which in turn improves soil organic carbon.

The general rule is that a 1% increase in soil organic carbon (SOC) leads to a 2% increase in soil water holding capacity (WHC), which has been calculated to equal an additional water storage capacity of 144,000 litres per hectare.

Some microbial inoculants are also able to enhance water use efficiency to increase drought resilience.

For more information visit: **soilcquest.org.au**