Mapleton Agri Biotec Pty Ltd

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RELEASE & CATCH TECHNOLOGY

The role of MAB inoculums in soil microflora and crop yields

Introduction

Crop plants accumulate yield by photosynthesis above ground and farmers are presented with a lot of products to address the need to have a strong canopy. But the major driver of high yields starts before this – a healthy vigorous root system is vital to gathering water and nutrients to feed the entire plant and allow photosynthesis to occur at high rates. The chemical and physical properties of soils are important and unfortunately some practices used in modern agriculture have degraded these properties. Heavy applications of fertilisers are part of the problem. Soil microflora and a healthy root system underpin high yields and this article will summarise how the use of high quality inoculums can re-invigorate soils and root systems and increase yields. Microbes and mycorrhizae act by several main mechanisms which are outlined below.

Nitrogen fixation

Diazotrophic microbes can fix nitrogen (N_2) from the atmosphere into NH_3 for the plant to use ($N_2 + 8H^+ \rightarrow 2NH3 + H_2$). There are many species in this family of microbes and some fix useful amounts of N and some don't. Our company has tested many species and we have found that the highest performing species can only be delivered reliably in a freeze-dried formulation. Some of our other products have microbe species that can be delivered as a powder because they are resistant to stresses but these species are not used to fix nitrogen – they have other uses. Crop producers looking for N fixing inoculums should examine the species present in any products and how they are formulated because these factors will affect the performance of the product.

After application to the crop roots nitrogen fixing microbes (other than *Rhizobium spp*. in legumes) colonise the rhizosphere (the soil zone very close to the root surface), the root surface itself, and also penetrate into the surface layers of the root. Some move inside the plant and live as endophytes. The microbes fix a moderate amount of N but it is fixed right on, or within, the root so it is all captured very efficiently by the plant. In addition, the N is presented to the crop very steadily right through the season, in contrast to the N spike that is produced by each application of N fertiliser. The effect of a steady supply of N right through the season has two benefits.

Firstly, it allows high yields with reduced N fertiliser rates. Reductions of 15 – 40% are possible with a high quality inoculum product. MAB's team can advise on the correct N reduction for your crop. Reducing N fertiliser rates reduces input costs and will help improve soils in the longer term. Secondly, the very steady delivery of N to the crop suits crops such as grapes and various fruit crops that need to avoid any spikes of N that will affect fruit formation or quality.

Local or imported? The question of whether microbe species native to the district can fix nitrogen better than the 'imported' species present in our products is sometimes discussed. Our product

development trials tested many N fixing species and it is clear that the likelihood of a local species performing at very high levels is low. The vast majority of species fix low levels of N. Producers should aim to use the best species of N fixers. However, having a strong, diverse local microflora is important in maintaining soil fertility and root health and the beneficial effect of our inoculums on native microflora is described below.

Root formation and efficiency

Microbes in our products produce a number of Plant Growth Factors (PGFs) including auxins that drive development of a root system with a lot of secondary roots (see image below). These capture all nutrients more efficiently, but N in particular. Nitrogen in the soil is not bound well and a high proportion of any applied N is lost to leaching and volatilisation. Roots of crops with enhanced secondary root systems capture more N before it can be lost and this increases Nitrogen Use Efficiency. The combination of N fixation by the nitrogen fixers plus better capture of applied N act together to improve the nitrogen status of the crop. This relationship between the crop root system and the microbes is very beneficial to both. The microbes increase nutrient availability, fix nitrogen and produce PGFs to stimulate the root system for the crop, while the crop releases large amounts of sugars and other compounds as root exudates that feed the microbes. This is a highly symbiotic relationship and the microbes in our products can only live in very close proximity to the roots.

Roots of pear tree showing excellent secondary root development six weeks after application of TwinN in Chile, November 2017.

Phosphorous and water status

Mapleton Agri Biotec tested sets of *Bacillus* and Mycorrhizae (VAM) species to find a combination that work well together. The result was a product (CataPult SuperFine) that works to increase Phosphorous (P) nutrition in crops. Phosphorous is often present at high levels in soils but is

unavailable because it is tightly bound. Highly alkaline soils commonly suffer from this problem. *Bacillus* species in our product produce organic acids that solubilise bound P and the mycorrhizae then capture it very efficiently and deliver it to the plant. Mycorrhizae colonise the roots and send out a large network of hyphae (extensive fine fungal threads) that capture P and other nutrients very efficiently. Mycorrhizae are particularly valuable for finding P in soils because P does not move in the soil so a zone rapidly develops close to the root called the 'zone of depletion'. In this zone the available P is captured by the root but P that is a short distance from the root is not 'found' by the root. The mycorrhizal hyphae network is so extensive it finds a lot more P than a root system alone.

An additional benefit of the mycorrhizal hyphae network is enhanced water capture and our product provides some protection from water stress. In crops where no irrigation is available or where it is limited at some times during the season this protection can help the negative effects of water stress on yield or quality from crops. This can help annual crops get through a dry spell during growth or to finish a good yield in the face of a dry finish to the season. In some countries CataPult is used to help fruit trees cope with water shortages that occur as irrigation supply becomes limited at the end of the fruiting season.

Root and soil health

Many soils have a depleted microflora and this limits crop productivity in several ways. A healthy, vigorous and varied microflora supports strong root growth as described above. The microbes improve the availability of most micronutrients and this is important. But an area of soil biology that is only recently becoming better understood is the interaction between soil microflora and root pathogens. There are specific mechanisms described in the scientific literature where microbe species, including some of the *Bacillus* species in our products, produce various compounds that directly inhibit some pathogens or prevent them taking up nutrients. In addition, root surfaces have a limited number of sites where infection can occur by pathogens and the presence of a very high density of beneficial microflora is believed to block access to infection sites. Our trials have shown that even within one *Bacillus* species there is a high degree of variation between different strains with some providing much better effectiveness while other strains are less effective.

In addition to the direct effects from *Bacillus* and other microbes on root and soil pathogens that have been described in the scientific literature our trials have shown that application of our inoculums boosts populations of native microbes. Trials by US Department of Agriculture showed that application of a herbicide reduced populations of beneficial microbes which resulted in increases in *Fusarium* infections. Application of one of our inoculums stimulated a return of beneficial microbe populations (such as fluorescent *Pseudomonads*) and an associated reduction in *Fusarium* infections. The stimulation of root growth and vigour from our inoculums increases root exudates and this provides a benefit to all the soil microflora, as well as to the microbes in our

inoculums. We believe that the stimulation of native microflora by our products is a valuable extra benefit from our inoculums.

Conclusion

Many modern crop growers recognised the value of building a good soil structure and a strong healthy microflora. For many producers this is a long term project and for many this is a difficult task because improving soils can require major changes to cropping methods. Using high quality microbial biofertilisers allows producers to reduce fertiliser use and stimulate development of a better root system and a beneficial microflora quickly and efficiently. This class of products is a valuable tool for producers who want to improve sustainability and profitability of farming systems.

References

The following is a series of general articles and reviews that relate to this article.

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