White Paper

Soil microbes; a potential answer to the damage from over-fertilising

It is well known that soil microbes interact with plants to supply nutrients, in particular nitrogen, typically supplied through synthetic inputs such as fertiliser.

In natural ecosystems, most nutrients including nitrogen (N) are bound in organic molecules which have limited availability to plants. To access these nutrients, plants are dependent on the action of soil microbes such as bacteria and fungi, which breakdown organic matter and mineralise nutrients[i].

Farming practices such as fertilisation, tillage, crop rotation and cover crops influence and alter soil microbial communities which in turn influence the agroecosystem[ii]. Soil microbial communities are often sensitive to nutrient inputs. For instance, nitrogen fertilisation typically reduces microbial biomass and respiration rates, with specific functional groups of microbes, including ammonia oxidisers and mycorrhizal fungi, often being very sensitive to the addition of nitrogen through fertilisers[iii].

Intensive agriculture is heavily reliant on the use of synthetic fertilisers. Currently, over 70% of the nitrogen utilised by plants comes from inorganic fertiliser sources. Intensive fertilisation practices are contributing to large-scale alterations of soil biochemical cycles, resulting in increased soil degradation, waterway eutrophication, and greenhouse gas emissions[iv].

In recent years, urease and nitrification inhibitors have emerged as mitigation tools in agriculture, to minimise nitrogen losses and reduce greenhouse and harmful gas emissions that are associated with the use of Nitrogen based fertilisers[v]. Although there are many benefits associated with the use of these inhibitors, little is known about their potential to enter the food chain, an event that may pose challenges to food safety.

The scale and severity of over fertilisation-induced problems is driving agricultural science to develop alternative ways to sustain plant nutrition while reducing the use of synthetic fertilisers.

One alternative is to replace synthetic fertilisers with organic inputs and supplement plants with beneficial root-associated microbes that can increase the availability of nutrients that are organically bound and are more stable in the soil compared to those supplied through synthetic fertilisers, and therefore less prone to leaching and volatilisation[vi].

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Numerous field studies have shown that use of organic amendments increases soil microbiological activity and is a beneficial strategy in crop production. However, it remains unclear how organic amendments shape both soil microbial community structure and activity and how these changes impact nutrient mineralisation rates[vii].

Plants are dependent upon the metabolic activities of soil microbiota for the cycling and access to soil-borne nutrients. Considering the potential environmental damage associated with high synthetic fertiliser use in intensive farming, it is important to consider and foster plant–microbe interactions to deliver a more sustainable agricultural system.

Nitrogen ‘pool’ in soils and reducing losses

The ultimate goal of nitrogen (N) management is to maximise N efficiency by increasing N fixation from the atmosphere, increasing crop uptake and minimising N losses to the environment. N is fixed, or combined, in nature as nitric oxide by lightning and ultraviolet rays, but more significant amounts of N are fixed as ammonia, nitrites, and nitrates by soil microorganisms. More than 90 percent of all N fixation to soils is performed by soil microorganisms.

As examples, there are free-living N-fixing bacteria, such as *Azotobacter*, *Clostridium pasteurianum*, and *Klebsiella pneumoniae*, while species of N fixing *Rhizobium* live in an intimate association with leguminous plants[viii].

Another important role of soil microbes is N mineralisation, the process by which inorganic N is obtained through decomposition of dead organisms and degradation of organic nitrogenous compounds. Also, enzymes produced by saprophytic bacteria and fungi are of great importance in nitrogen cycling in ecosystems since they have high substrate affinity and are responsible for breaking down proteins, to small peptides and amino acids, that are a source of ammonium in soils. Activity of these enzymes is seasonal, with higher activity in spring and autumn[ix].

Ammonium is a highly advantageous source of nitrogen in soils, being positively charged it combines with particles in the soil and does not leach. Also, ammonium does not get biologically converted to a gaseous form and is therefore stable in wet soil conditions. Ammonium is converted biologically to nitrate, plant available nitrogen, through the process of nitrification[x].

One of the common causes of N losses is temporary N immobilisation or lock-up. During this process nitrate and ammonium are absorbed by soil microorganisms and consequently become unavailable to crops. When the microorganisms die, the organic N contained in their cells is converted by mineralisation and nitrification to plant available nitrate[xi].

Incorporation of organic materials with a high carbon to nitrogen (C:N) ratio will increase biological activity and result in a greater demand for N, and thus result in N immobilisation. Immobilising mineral N because microbial biomass tends to retain N or extract it from the inorganic pool[xii]. Organic material with a C:N ratio less than 25:1 leads to N release or mineralisation due to the excess of N relative to available C. The N released is primarily ammonium.

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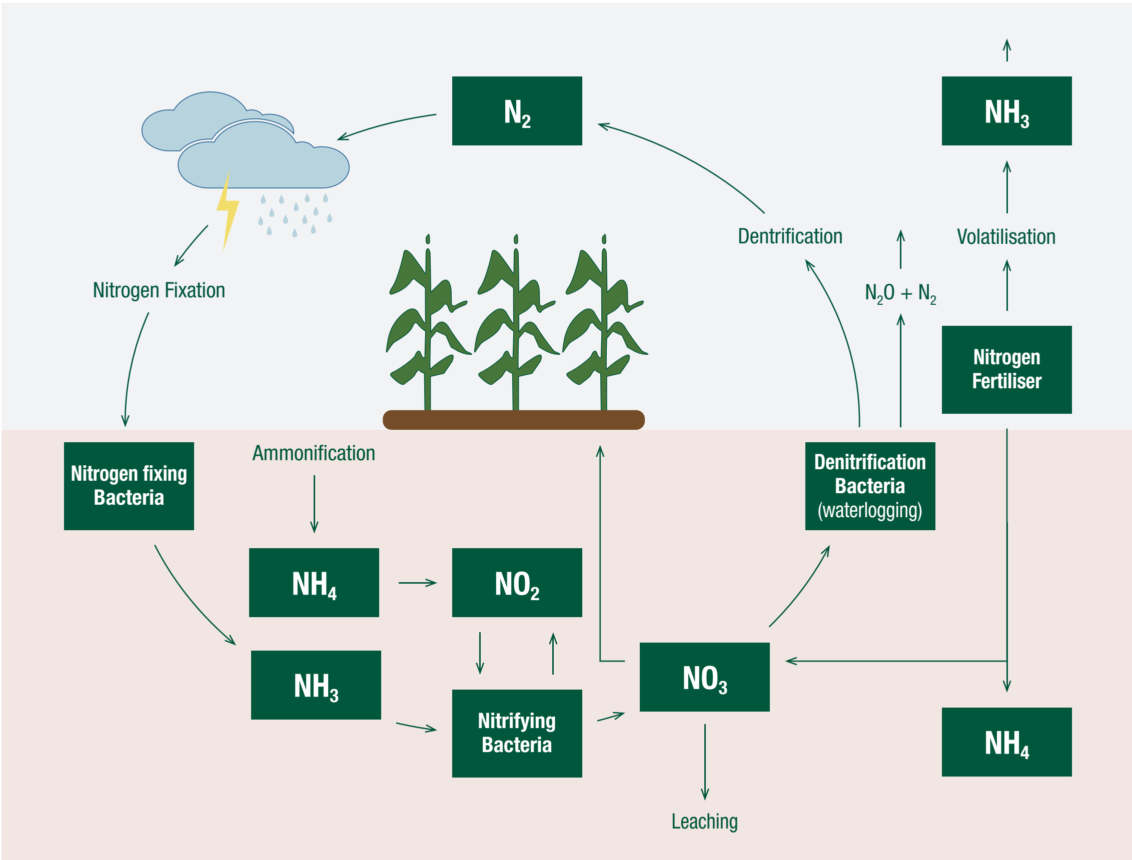
This movement of N between immobile and plant available sources is referred to as nutrient cycling. The cycling of nutrients plays an important function in not only binding with free N that may leach out of the soil, but also breaking down forms of bound N that are not plant available, and eventually releasing the N in plant available forms.

Soil conditions play a role in determining N cycling. Aerobic soil conditions reduce the rate of denitrification (N loss). The anaerobic microbial process that occurs in low aerated, compacted, or flooded soils, take nitrates, convert it into nitrogen gas (N_2) which is immediately lost to the atmosphere.

The Nitrogen Cycle



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Regenerate soil properties and minimise nutrient loss pathways with BioAg

Modern farming technologies, including use of soil inoculants, allow growers to gradually regenerate degraded soils, increase its fertility (nutrient reserves and availability), and restore soil buffer capabilities.

BioAg is a manufacturer of microbiological biostimulants through a unique fermentation technology. It's a revolutionary combination of essential nutrients and metabolites (precursors of proteins and amino acids) for your crops or to stimulate microbial activity in the soil. The end result is improved plant vigour, yields and quality.

BioAg *Soil & Seed*® is formulated to improve soil microbial activity. It acts as an excellent soil inoculant, feeds and expands the volume and diversity of beneficial soil micro-organisms, including bacteria, fungi, yeast and protozoa. These organisms perform a wide variety of tasks that are important for both soil health and profitable farming systems. Treated soils demonstrate improvements in:

- biological properties (nutrient solubilisation and accessibility, nutrient cycling, nitrogen fixing, disease resistance, soil carbon increase, water-holding capacity and residue break down).
- physical properties (soil aggregation, water infiltration and aeration).
- chemical properties (nutrient availability, elimination of nutrient loss pathways, toxic agrochemical's by-products breakdown).

Soil & Seed provides a high survival rate for soil inoculated beneficial microbes even in degraded soils and acts as a plant growth stimulator due to its complex composition that includes carbohydrates, proteins, humic compounds, vitamins, macro- and microminerals and free L-amino acids.

The growth of soil microbes is usually carbon-limited, so the high amounts of sugars, amino acids, and organic acids that plants deposit into the rhizosphere represent a valuable nutrition source. However, deposition of this labile carbon does not necessarily encourage the growth of favourable microbes, as pathogenic strains also use these molecules as growth substrates.

Plants have evolved recognition mechanisms to classify beneficial microorganisms from pathogenic. Specific molecules in root exudates contribute to shaping the specific microbial population, such as flavonoids, strigolactones, or terpenoids[xiii].

Soil & Seed delivers microbial 'food' together with beneficial soil microbes that increase competition to pathogens.

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Our focus is to measure and analyse soil and develop sustained, cost-effective nutrition programs that meet the soils and crop's requirements, and help the grower achieve yield and quality goals.

BioAg Area Managers and distributors work directly with growers to develop fertility programs across a range of crop types. Our programs deliver improved nutrient use efficiency, utilisation, uptake and cycling.

Talk to us about how a BioAg program could reduce your nutrient input costs, including clever use of N and increasing your crop yields and quality for maximised profit.

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