Soil Health - Myth Vs Fact

BUSTING THE MYTHS

Throughout history there are many cases of widely held beliefs, often driven by commercial and political interests, that turn out to be wrong. For example, smoking was considered healthy until the mid-1900s.

In agriculture, the industrial approach to food production is on an unsustainable path - failing to feed our growing demand and having an unacceptable contribution to environmental pollution, chemical toxicity, antibiotic resistance and poor nutrition. Fortunately, technological advances and experiences can dispel some notable doctrines in conventional agriculture and proven alternatives are available as exemplified below.

They Say…	The Facts
'NPK' are the primary three limiting nutrients of significance.	• At least 16 mineral elements are required for a healthy farm system. • Reliance on soluble 'NPK' fertilisers supresses natural nutrient cycling, microbial activity and the building of soil carbon. • The 'NPK' paradigm's inherent waste of nutrients represents a significant cost - borne by farmers. • Good nutrition practices feed the soil, not the plant.
Lime/calcium is primarily used as a tool for correction of soil acidity.	• Calcium is a core foundation mineral - a base fertiliser - not a tool for correcting acidity. • The importance of calcium for nutrition and soil structure cannot be overstated. • pH is not an indication of calcium availability. • In biologically healthy soils with nutrients at appropriate levels, pH will be corrected by natural biological processes.
You can't avoid a large portion of applied phosphorous (P) being 'locked up', remaining unavailable to the plant.	• More phosphorus is made available to plants when microorganisms are active in the soil. • In healthy soils, a dynamic exchange of phosphorus occurs between significant reserves (humus, undegraded organic matter, soil particles and in solution) and plants – all of which is facilitated by active soil biology converting phosphorus to plant available form.
High rates of soluble nitrogen (N) are needed to maximize crop and pasture growth.	• High soluble nitrate levels impede the normal processes by which plants most effectively assimilate nitrogen. • Soluble nitrogen provides a short term 'sugar hit' but pastures accumulate excessive nitrate which can cause metabolic disorders in cows and affect milk quality. • Only 10-40% of applied soluble nitrogen is used by the plant. The balance is either lost to the atmosphere as gaseous nitrous oxide (N2O), formed by undesirable bacteria, or leached into waterways. Such waste is a direct cost to the farmer.
Potassium (K) is easily leached or 'locked up', therefore, plenty of soluble K is needed to feed the plant.	• Similar situation as phosphorous. In healthy soils, significant quantities of potassium are held in dynamic balance between humus, un-degraded organic matter, soil particles and in solution. • Active soil biology releases potassium from these reserves in plant available form. • Replenishment should aim for recommended levels of potassium as a % of base saturation.

The 'NPK' Paradigm

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They say…

Soil nutrient management primarily needs to be focused on three key nutrients – nitrogen (N), phosphorous (P) and potassium (K).

The Facts

- The 'NPK' approach is an over simplification of a complex system. It is conceived on the incorrect belief that water solubility of chemical fertilisers implies equivalent adsorption by plant roots and that only the elements used in large quantities need attention.
- At least 16 mineral elements are required for fully productive and resilient pastures and crops - not just 3 or 6. Farm product volume and quality will only be as good as the most limiting elements – including those with low commercial value, such as calcium.
- The 'NPK' approach delivers soluble nutrients directly to the plant and suppresses microbial activity because the microbe's function is bypassed. Less microbial activity means less building of humus, therefore, less storage of carbon and other nutrients in a form which is then made available to the plant - again through soil microbes.
- The 'NPK' story ignores carbon as it believes the plant's demand is met from an unlimited source of CO_2 in the air. Yet, in the absence of other practices to build soil humus, carbon levels decline over time and the health of soil and plants are compromised. Soil biology and plants must, therefore, source a portion of their carbon budget from reserves in soil humus.
- The effect of 'NPK' systems in suppressing the building of humus, leads to long term degradation of soil structure, reduced holding capacity and transport of water in soil.
- 'NPK' based farming is inherently wasteful. Conventional systems apply all three nutrients in far greater quantities than are used by the plant because we now know that a large portion is either locked up or lost by leaching. The financial cost of wasted nutrients is borne by the farmer, while the wider community feels environmental impacts caused by nutrient leaching.

The Proven Alternative

Alternative approaches to farm nutrient management focus on healthy and active soil biology and regulating **ALL** mineral elements to replenish those exported in farm produce. This makes use of efficient natural reserves and nutrient cycles - building soil humus to levels that underpin self-sustaining production.

In a biological system, microbe friendly fertilisers are used for replenishment of exported minerals.

Fertiliser practices should feed the soil, not the plant.

Calcium (Ca), pH and Magnesium (Mg)

BUSTING THE MYTHS

They Say…

Lime/calcium is primarily used as a tool for correction of soil acidity.

The Facts

- Calcium is a core foundation mineral, required as a critical component in all biological systems. Calcium should be viewed as a base/capital fertiliser, not a tool for correcting acidity.
- In biologically healthy soils with nutrients at appropriate levels, pH will be corrected by natural biological processes.
- pH is a function of free H+ ions, not calcium level. pH is not an indication of calcium availability.
- Calcium plays several critical roles in a wide range of areas, including: soil structure; carriage and uptake of other minerals by plants; cell wall structure; cell division; protein synthesis by microbes and plants; and, prevention of infection by pathogens.

They Say…

Ca:Mg ratio of soil is important in evaluating soil fertility.

The Facts

- Balancing soil fertility must consider calcium and magnesium (and other cations) expressed as a % of base saturation, or cation exchange capacity (CEC), not as a ratio of total calcium to total magnesium. On their own, ratios between these elements can be misleading - they say nothing of the quantities present and available to the soil, plants and microbes.
- If either calcium or magnesium are out of balance (a deficiency or surplus) detrimental effects will be observed somewhere along the biological chain, either as poor production or susceptibility to disease.

The Proven Alternative

Calcium and magnesium are top order priorities in management of farm nutrients and soil structure. Their importance in nutrition and as catalysts for soil structure cannot be overstated. They have been significantly under rated in conventional agricultural systems, largely because they are of low commercial value.

Recommendations of cation exchange levels vary with soil texture. Typical suggestions are for calcium at 65-70% of base saturation and magnesium can occupy 15-20%. Combined, calcium and magnesium are often suggested to be around 80% of base saturation. The remainder of CEC is taken up with potassium, sodium, hydrogen and, to a lesser extent, other important minerals.

The critical factor is having an appropriate amount of each nutrient to suit conditions.

Phosphorous (P) availability and uptake

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They say…

You can't avoid a large portion of applied phosphorous being 'locked up', remaining unavailable to the plant.

The Facts

- The degree to which bound phosphorus becomes available to plants is determined by the biological health of the soil, availability of other nutrients and soil pH. The considerable reserve of phosphorus 'locked up' in most soils can become available to the plant if biological activity is strong and other nutrients are sufficient to support the microbes.
- The farmer pays dearly for the large portion of applied soluble phosphate being 'locked up' in conventional systems, which do not encourage conditions for release of this important nutrient.
- Soluble phosphorus fertiliser may contain undesirable compounds such as cadmium, which can accumulate over several years to reach toxic levels.

The Proven Alternative

Biologically healthy soils contain a large reserve of phosphorous dispersed in a dynamic balance between several 'pools' - partially decomposed organic matter, humus, soil particles and soil solution. Microbes extract the phosphorous, making it available to plants.

In a healthy system, the amount of phosphorous replenished through fertiliser application should only reflect the amount being removed with farm produce.

Preferable forms of phosphorous are insoluble, for example, reactive phosphate rock or organic material (compost/manure) which facilitate the role of microbes in natural nutrient cycling.

Soluble Nitrogen (N) and growth

They say…

High rates of soluble nitrogen are needed to maximize crop and pasture growth.

BUSTING THE MYTHS

The Facts

- High soluble nitrate levels impede the normal processes by which plants most effectively assimilate nitrogen. Several consequential impacts follow, including: reduced level of soil microbial activity; suppression of natural N-fixing microbes; reduced organic matter (carbon); and, loss of soil structure.
- Flooding soils with soluble nitrogen, which is easily available and highly mobile, provides a false 'sugar hit' resulting in lush green plants. However, this generates an imbalance of minerals, unfavourable amino acids and excess of nitrates in the plant. Longer lasting damage to soil biological health serves to compound the problems.
- In conventional systems, plant growth becomes increasingly dependent on soluble nitrogen, however, the effectiveness steadily reduces over time, explaining why farmers are seeing declining responses to their nitrogen applications.
- A range of metabolic disorders are linked to excessive nitrate/nitrite consumption in dairy cows, including: mastitis, laminitis, liver dysfunction, lameness and infertility.
- Only 10-40% of applied soluble nitrogen is used by the plant. The balance is either lost to the atmosphere as gaseous nitrous oxide (N_2O), formed by undesirable bacteria, or leached into waterways taking other useful cations with it (including calcium, magnesium and copper).
- Applied nitrogen lost from the system is an unsustainable waste of resources – a cost borne by the farmer. Additional significant costs are borne by the community for the environmental damage to waterways downstream of the farm.
- Gaseous nitrous oxide emissions are 300 times more potent as a greenhouse gas than CO_2 and have a half-life of some 115 years.

The Proven Alternative

Biologically healthy soils have demonstrated equivalent or better production when a fraction of the traditional amounts of synthetic nitrogen are applied – often only as folia sprays.

In balanced, biologically healthy soils with good organic matter, significant reserves of nitrogen are contained within the living and decomposed organic matter (humus) and made available to the plant on demand, through microbial activity.

An extraordinary range of improvements in farm health and productivity are evident when the system is 'weaned' from a reliance on soluble nitrogen in favour of biologically healthy soils.

Nitrogen (N) atmospheric fixation

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They say…

Legumes are the only crops/pastures able to effectively fix atmospheric nitrogen, through association with rhizobia.

The Facts

- Presently, the primary source of field nitrogen-fixation in agriculture is through a symbiotic relationship between legumes and rhizobia bacteria. However, since the discovery of free living nitrogen-fixing bacteria in sugarcane in the 1990s, several strains have shown strong potential for converting atmospheric nitrogen into a plant usable form.

- Free living nitrogen-fixing bacteria are found in the soil and as endophytes in plant leaf tissue. Common genera include Azospirillum and Azotobacter.

- Bacterial fixation of atmospheric nitrogen is curtailed when other sources of nitrogen are available.

- Products are available to enhance the expression of free living nitrogen-fixation for non-legume pastures and crops.

- Several strains of nitrogen-fixing bacteria have been found in leaf tissue of large, fast growing poplar trees and pine trees growing in particularly poor soils. Importantly, many of these bacterial strains have been transferred to agricultural plants in pot trials, and show continued expression of nitrogen fixation. Research aimed at confirming potential for commercial application is in progress.

The Proven Alternative

A biological farming system not only promotes growth and activity of free-living nitrogen fixing bacteria but also supports the building of nitrogen reserves through decomposition of organic matter to humus.

The considerable reserve of nitrogen contained in humus is made available to plants through microbial activity.

Potassium (K)

They say…

Potassium (K) is easily leached or 'locked up', therefore, plenty of soluble potassium is needed to feed the plant.

The Facts

- Potassium is an essential nutrient, performing several roles and has multiple interactions with other essential nutrients such as calcium, magnesium, boron and iron. This fact is obscured by the over simplified 'NPK' approach.

- In a conventional, soluble fertiliser regime with limited organic matter and low biological activity, potassium must either:
  (1) be adsorbed to colloidal exchange sites where it is locked up and remains unavailable; or,
  (2) remain in solution as a salt where it is readily leached or easily adsorbed by plant roots. That is, there is no dynamic or reversible movement between states of potassium in the soil. Excessive plant uptake of soluble potassium is common, causing toxic effects to the plant and grazing animals.

- Under the classic 'NPK' model, potassium losses through leaching and chemical adsorption are irreversible.

- The majority of potassium used under the 'NPK' model is sold as muriate of potash (KCl), also called potassium chloride. When potassium cations attach to soil colloids the remaining chloride anion has the potential to form chlorine. In some conditions chloride ions easily bond with calcium, leaching both elements out of the root zone.

- Potassium fertilisers are among the most expensive on the basis of $ per kg of elemental potassium. Considerable wastage and damage associated with the 'NPK' approach is borne by the farmer.

The Proven Alternative

Poor availability of potassium is an issue which can be addressed by enhancing soil biological activity through several practices, including the use of microbe friendly potassium fertilisers.

Recommended potassium base saturation is typically around 3%, however, this varies with soil types. Too much potassium can displace or 'crowd out' calcium and magnesium, resulting in deficiency of these two minerals.

In a biologically healthy system, where soil organic matter exceeds 2%, considerable and available reserves of potassium are stored in humus, on soil particles and in partly degraded organic matter.

The dynamic balance maintained between these 'pools' and in solution is regulated by soil biology which draws from the reserves and make it available to plants.