Practical Guide:

Nature based solution to combat rising fertiliser costs

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Inorganic fertilisers and its issues

Many nutrients are essential for plant growth with the primary nutrients being Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus and Potassium. The latter three are commonly found in inorganic fertilisers which have historically been added to agricultural land to optimise plant growth, and thus production. However, in recent years there has been a sharp increase in fertiliser costs as a result of multiple factors, including the rising energy demands required to synthesise the fertiliser, issues with supply, and socio-economical trade issues. Furthermore, the addition of inorganic fertilisers can have harmful impacts of the environment, such as leaching into watercourses, depletion of soil quality, and contribution to greenhouse gas emission. As such, alternative, more nature-based solutions to provide plants with sufficient nutrients has become a topic at the forefront of modern agriculture.

Nutrient cycling importance in agriculture

Nutrients essential to plant growth are in constant flux, changing state and cycling through the soil, living things, and in some instances the atmosphere. Understanding nutrient cycles is important to understand how the soil biota and crop plants interact to ensure optimal growth. The nitrogen cycle, for example, heavily relies on the actions of bacteria transforming atmospheric nitrogen, which is unavailable to plants, into nitrates that can be up taken by plant roots (Figure 1). Crucial to this cycle, is the maintenance of healthy microbe communities to fix atmospheric nitrogen making it available to plants and to also return organic nitrogen back into the system through the action of decomposition.

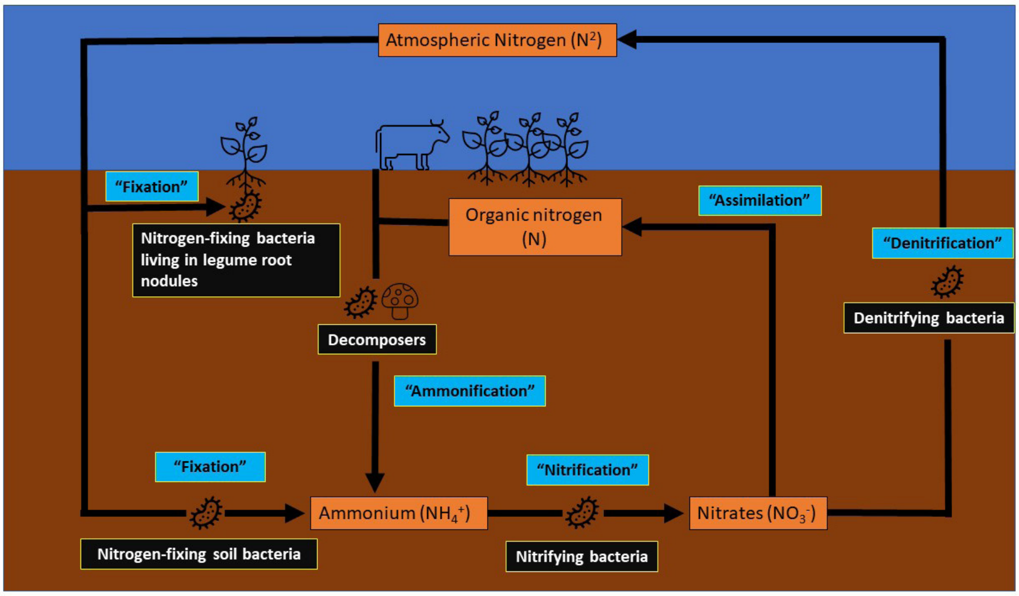

Figure 1: Nitrogen cycle highlighting the crucial role that bacteria and fungi play in capturing and recycling nitrogen

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Soil health and fertiliser requirement

The condition of soil can greatly influence the requirement of additional nutrients. A soil in good condition will require a much lower quantity of nutrients than soil in poor condition. A soil in good condition is recognised by its physical, chemical and biological aspects and issues in any of these aspects will limit nutrient uptake and yield. A soil in good condition will have little compaction, good organic matter, the correct pH, and a rich diversity of bacteria, mycorrhiza, protozoa and other invertebrates such as earthworms and springtails. Understanding the soil and working to regenerate can result in a more sustainable farming method which requires lower synthetic inputs. Below are a range of nature-based solutions which aim to improve the aspects of soil which dictate nutrient uptake to reduce dependency on fertiliser application.

Livestock integration and organic fertilisers

While natural organic fertilisers are already widely utilised across the UK, there is scope for organic fertilisers to be implemented on cropland through livestock integration, and the use of processed organic fertilisers to provide an alternative to inorganic fertilisers. Livestock integration onto cropland provides a source of nutrients through animal manure. This addition of manure can also provide a source of organic matter boosting soil health. Processed organic fertilisers can include biosolids. These are produced through treating sludge from wastewater treatment plants, which allows nutrients to be captured in a form that can then be applied to agricultural land helping to close the nutrient cycle and enhancing productivity. However, there is concern that processed fertilisers can provide a source of contamination including microplastics and consideration should be given to sourcing such organic fertilisers. When processed and used appropriately, these organic fertilisers can provide a cost-effective way of improving soil fertility and quality.

Figure 2: Integrating sheep grazing in winter wheat at Balbirnie Home Farms

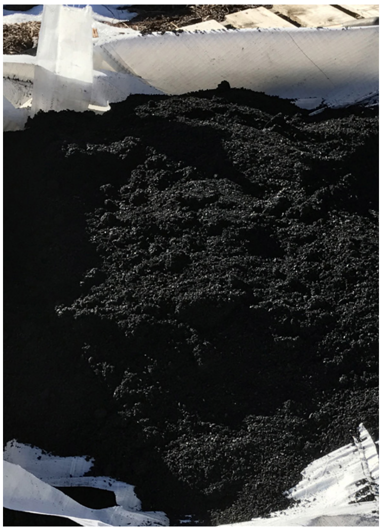

Figure 3: Biochar

Biochar

Biochar is charcoal-like and produced from crop residues, animal manure and biological wastes. Biochar is known to improve the fertility and water holding capacity of soils, as well as reducing pollutants and greenhouse gas emissions. Through benefiting soil health, it decreases the level of fertiliser required to maintain agricultural output. Studies have shown biochar application can increase phosphorus and potassium uptake from plants, reduce nitrate leaching, and enhance nitrogen fixation. Alongside the agricultural production benefits, biochar provides a range of environmental and ecological benefits through the stimulation of soil ecosystems which can aid carbon sequestration.

Lime application and soil pH

The condition of the soil can greatly impact the availability of some plant nutrients (e.g. Phosphorus, Nitrogen and Potassium). An example of this is the soil pH. The ideal pH of soil depends on land use and soil type. A soil pH of between 5.8 and 6.3 is recommended for optimal uptake of nutrients in plants.

Natural processes alongside the use of inorganic fertilisers tend to result in soils becoming more acidic over time. Phosphorus uptake, for example, is directly affected by soil pH, with acid soils resulting in phosphorus becoming less accessible to plant absorption, highlighting the importance of regular soil testing. Regular testing will help to identify when the application of lime is needed to restore pH to the optimal level for nutrient uptake by plants.

Multi species swards

A multi-species sward is defined as a grass/forb mixture which includes two or more species. As plant species respond differently to environmental conditions, increasing diversity ensures resilience during periods of drought or flooding. The variation in root structures that comes with multi-species swards improves soil condition, breaking up the soil which improves drainage and biological activities. Additionally, the variation in root depth allows for nutrients deeper within the soil to be tapped into and brought to the surface. The inclusion of nitrogen fixing legumes additionally allows for more available nitrogen within the soil. These nitrogen fixing species convert atmospheric nitrogen into ammonia which can be used to make plant protein, amino acids and DNA.

Figure 4: Multi-species sward

The combination of these benefits of multispecies swards can result in a reduction of synthetic fertiliser application with additional benefits to soil health and wider farmland biodiversity. Multi-species swards can also help to stabilise yields under a range of environmental conditions, and maintain yields whilst minimising the need for inorganic fertilisers.

Biofertilisers and mycorrhizal symbiosis

Biofertilisers are 'biological fertilisers', meaning they contain living organisms. When applied to soil, these living organisms increase the rate of nitrogen fixation and phosphate solubilisation increasing the supply or availability of nutrients promoting plant growth. Additionally, this acceleration of microbial processes helps to restore natural nutrient cycles and build organic matter in soils.

Mycorrhizal symbiosis is the mutual association between plant roots and fungi, where fungi provide nutrients and water to plant roots, while the plant provides the fungi with sugars. Mycorrhizae are made up of string like filaments that run under the soil, stretching from roots to surrounding soil unavailable to the plant. The relationship between fungi and agriculture is becoming more attractive due to observed increases in nutrient uptake as well as the fungi's ability to increase water uptake during times of drought.

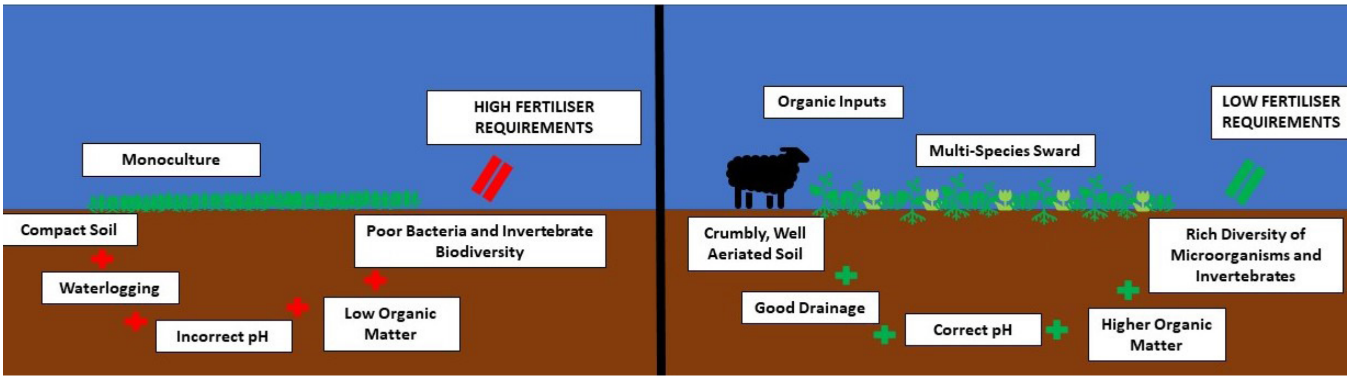

Figure 5: Aspects of poor soil health and land management resulting in higher fertiliser requirements (left) and good soil health and land management which require a lower level of fertiliser application.

Through a variety of nature-based solutions farmers can capitalise on the ecosystem services that healthy soils and plant communities provide. This in turn will help stabilise and maintain yields, reducing reliance on synthetic pesticides and building resilience into the farming system.

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