WHY MORE GROWERS ARE EMBRACING ENHANCED EFFICIENCY FERTILISERS

A whitepaper by Advanced Nutrients

ABSTRACT

In 2011, Australian growers used more than 1,098 thousand tons (Gg) of nitrogen fertiliser on crops, and 533 Gg of phosphorous and potassium. This enormous investment is designed to extract greater yield, and more profit. Yet it's a known fact that crops don't use most NPK fertiliser that is applied to the soil.

Enhanced efficiency fertilisers (EEF) are specifically designed to improve uptake of NPK fertilisers. This paper shows how they offer growers an opportunity to reduce fertiliser losses and/or improve crop yields. This can enable growers to cut input costs, increasing the return on investment.

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EXECUTIVE SUMMARY

Australian growers use a huge amount of fertiliser each year. And the cost is enormous. Since the actual amount of fertiliser absorbed by crops is generally quite low (often as little as a third of the amount of fertiliser applied to the soil) there exists significant potential to decrease fertiliser use if absorption efficiency can be increased. This paper examines enhanced efficiency fertilisers — a new breed of nitrogen and phosphorous fertilisers that promise exactly that.

Some the key findings about enhanced efficiency fertilisers in this whitepaper:

- In 1961, Australian farmers used 35 thousand tons (Gg) of nitrogen on their crops. By 2011, this numbers had grown to more than 1,098 Gg of nitrogen fertiliser — a thirty-fold increase in quantity.
- Growers also applied 533 Gg of phosphorous and potassium.
- More than half of applied nitrogen fertiliser never reaches the crop and nearly three-quarters of all phosphate is wasted.
- EEFs designed for agricultural use control fertiliser release or alter the chemical reactions that cause nutrient losses.
- Nitrogen EEFs are usually in granular form, while phosphorous EEFs are generally liquid concentrates.
- Various field trials show that nitrogen EEFs markedly increase use-efficiency in crops, and boost yield as much as 30%.
- Growers can combine enhanced efficiency fertilisers with a number of agricultural techniques to further improve crop fertiliser-use efficiency.

The challenge of traditional NPK fertilisers

In 1961, Australian farmers used 35 thousand tons (Gg) of nitrogen on their crops. By 2011, this numbers had grown to more than 1,098 Gg of nitrogen fertiliser — a thirty-fold increase in quantity.

Growers also applied 533 Gg of phosphorous and potassium. This is an enormous annual investment in fertilisers, and every bit of fertiliser that isn't absorbed by the crop to promote stronger, faster growth is a huge cost impost on growers.

However, the key problem is that these fertilisers are simply not used efficiently.

Australian dryland wheat, for example, on average absorbs only 41% of the nitrogen growers apply. This might be marginally better than the estimated worldwide efficiency of nitrogen for cereals (33%) but the reality is that agricultural crops — whether it's cereals, sugarcane, pasture, horticulture, cotton, and oilseeds — seldom assimilate more than 50% of the nitrogen added.

In fact, plant uptake for a range of crops and pastures in Australia varies from 6 to 59% of the nitrogen farmers apply to the soil. Bananas and flooded rice are the least efficient of the crops studied (6–17%).

The story is similar for phosphorous — as much as 70% of the soil-applied phosphorous fertiliser is never absorbed by the root system to fuel growth. This is especially so in Australia, which features highly fixative phosphorous-deficient soils that rapidly lock plant-available phosphorous up in unavailable inorganic forms.

And since all fertilisers eventually face the problem of diminishing marginal returns (ie: an additional kilogram of NPK delivers less growth than the previous kilogram), growing in crop yields (and thus profit) becomes a significant challenge. That's not to mention that over-fertilisation also eventually causes significant local environmental degradation, too.

At this point, minimising nutrient losses becomes crucial to improving return on investment.

The good news for growers (and consumers) is that enhanced efficiency fertilisers (EEFs) offer a way forward. There are a number of EEFs, however this paper will concentrate on one of the most promising types: controlled-release fertilisers — either polymer-coated granular types, or liquid solutions with organic, bio-catalyst additives.

What are enhanced efficiency fertilisers?

Slow-release fertilisers have been available for over 25 years. However, few of these were available (or designed) for broadacre crops. Instead, their market has been horticulture or turf applications.

EEFs are modern formulations designed for agricultural use that control fertiliser release or alter the chemical reactions that cause nutrient losses. The mechanisms or products include fertiliser additives, physical barriers or different chemical formulations.

These additives improve fertiliser availability by reducing nitrogen losses from volatilisation, de-nitrification, leaching and immobilisation.

They may temporarily block bacterial or enzymatic processes in the conversion of urea to ammonium or ammonium to nitrate.

Phosphorus products can either be polymer coatings or polymers that shield phosphorous from the reactions that create less soluble phosphates.

How EEFs increase crop nutrient uptake

Nitrogen-based polymer EEFs (usually based on urea) employ a hard coating to improve the efficiency of nitrogen uptake by crops and cut fertiliser wastage.

The coating is generally composed of organic carbon as well humic, fulvic, ulmic and amino acids, plus melanins, peptides, polysaccharides, vitamins and minerals.

After sowing, the hard exterior melts into the soil first. This creates a protective blanket of organic elements with an enormous surface area of negative charges to bind-up the positively charged ammonium as the interior fertiliser granule dissolves.

This stabilises the nitrogen within the soil and controls its release into plant-available forms of that crops can absorb through the root system.

A microclimate of microbial activity develop around the granule, creating a controlled release effect so nitrogen is carried through the microbes' life cycle, only becoming available when they die and are oxidised.

With these coated products, the more stable complex:

- Slows these reactions, reducing wastage of nitrogen nutrients
- Promotes an increase in microbial communities in the soil, creating a greater biological storage of nitrogen.

Enhanced efficiency phosphate fertilisers are most often found in liquid form. Similarly, the organic catalysts and supplements bind with the phosphate molecules to reduce "tie-up" into insoluble phosphate forms.

All soluble phosphorous eventually reverts to the rock phosphate which was the original source for the fertiliser. Additives slow this inevitable reversion process.

The aim is improved soil penetration, mobility and plant uptake of phosphorous. This increases long-term availability in soluble forms for sustained uptake throughout the growing cycle.

The liquid form enables deeper, wider soil penetration (especially compared to granular phosphates) so more phosphorous reaches a greater proportion of the crop root system.

The key advantages of enhanced efficiency fertilisers

Ultimately, the aim is to raise nutrient-use efficiency of nitrogen and phosphorous.

At their best, controlled-release enhanced efficiency fertilisers can make it possible to use less fertiliser and still supply the nitrogen or phosphorous plant requirements with a single application, matching soil concentrations of nutrients to crop demands throughout the entire growing season.

This delivers growers several benefits:

- **Cost reductions.** Labour, application and equipment costs are reduced because growers apply less fertiliser less often.
- **Quality and yield improvements.** Crop quality is better and more uniform, and in some cases yield per hectare is higher.
- **Better fertiliser-use efficiency.** The crop uses more nitrogen and phosphorous is, and less is lost to the ground (fixation), the air (volatisation) and to water erosion (leaching)
- **Greater profit.** Whether through lower costs, or increased yields (or a combination of the two), growers are able to increase their return on investment.
- **Reduced impact on the environment and human health.** High levels of nitrogen volatisation and leaching acidifies soils, causes algal blooms in lakes, rivers and estuaries and decreases biodiversity.

For some growers, EEFs can even offer a public relations or marketing benefit.

What are the results?

Research reveals that using combined controlled-release nitrogen fertiliser significantly reduces volatisation and leaching losses.

One 2008 field trial examined performance of rice, wheat and vegetables in dry upland fields and in flooded conditions.

In upland fields, volatisation losses were only 2% compared with 33% with traditional granular urea while leaching losses were 4%, as opposed to 41%.

In flooded (rice) fields, 21% was lost to volatisation when using biosolids-inorganic nitrogen. When growers used normal granular urea, 57% of the nitrogen was lost to volatisation. Leaching losses were 13% versus 86%.

Crucially, this substantial improvement in nitrogen-use efficiency translated into higher grain yields for rice, wheat and vegetables: specifically, growers in Ghana, Burundi and Rwanda obtained up to 30% higher yields with controlled-release fertilisers from okra, cabbage and sweet pepper.

Studies also indicate that bio-catalyst-supplemented liquid phosphate is up to three times as efficient at delivering nutrients to the root system — increasing available soil phosphate by 30% to a depth of 45 centimetres.

Other field trials conducted at Quirindi in New South Wales revealed that humic acid-coated urea significantly reduced nitrogen loss and enhanced nitrogen uptake by dryland wheat. It also boosted dryland pasture yields compared with granular urea alone. The study also found that addition of humic acid to urea reduced ammonia loss in acidic soils.

Techniques for getting the most out of EEFs

Growers can also combine enhanced efficiency fertilisers with a number of techniques to further improve crop fertiliser-use efficiency.

- Using soil and plant testing to make best use of indigenous nitrogen.
- Using the optimal form, rate, method and time of application of the fertiliser.
- Incorporation or deep placement of fertiliser (to reduce volatisation).
- Using split applications—several applications of small amounts of fertiliser during the growing season can be more effective a single large dose at the beginning of the season. However, this does increase labour costs.
- Minimising application in the wet season to reduce leaching and denitrification.
- Delaying the supply of fertiliser until a substantial canopy has developed.

In particular, matching the type of fertiliser with rainfall and moisture conditions in the soil could result in appreciable reductions in nitrogen loss —delivering maximum nitrogen-use efficiency for growers.

Top nitrogen users in the broadacre sector of Australian agriculture are those producing cereals, sugarcane, cotton, and pasture. Dairy farmers might apply as much as 300 kg of nitrogen per hectare each year to their pastures.

Each of these is likely to benefit from enhanced efficiency fertilisers because their potential to reduce fertiliser use (and thus input costs) is the largest.

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✆ 1800 244 009
service@advancednutrients.com.au

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