UREA-BASED NITROGEN FERTILISERS

THEIR BENEFITS, AND HOW TO MAXIMISE YIELD WHILE MINIMISING COSTS

A whitepaper by Advanced Nutrients

ABSTRACT

Growers can lose 30-40% of the nitrogen they apply to their crops when they use normal, commercially available granular urea. This is an expensive problem that inflates growing costs and reduces yields.

Evidence shows that Black Urea® offers growers a urea-based fertiliser that improves nitrogen use efficiency, lowering fertiliser wastage, reducing input costs and maximising return on investment.

EXECUTIVE SUMMARY

You have to apply urea fertilisers to maximise yields from your cotton crops. But the truth is that a large proportion of that either washes away, or simply evaporates into the air.

This paper examines the benefits nitrogen delivers to growers, how nitrogen leaching occurs, why traditional granular fertlisers are especially vulnerable — and which climate and soil conditions exacerbate nitrogen loss.

It also shows how a coated urea fertiliser called Black Urea® improves nitrogen use efficiency, lowering fertiliser wastage, reducing input costs and maximising return on investment.

Some of the key findings in this whitepaper:

- In the field, it's been observed that around 40% of nitrogen released by fertiliser reaches crops
- Well-managed research plots achieve efficiency levels of up to 90%
- High temperatures and alkaline soils accelerate nitrogen leaching
- Black Urea® slows these reactions, reducing costly wastage of nitrogen nutrients
- Up to 30% more nitrogen reaches the cotton crop
- Testing shows Black Urea® retains at least 45% of its nitrogen for crops after 10 weeks; white urea no more than 5%
- Black Urea® promotes microbial communities, creating a greater biological storage of nitrogen for gradual release to cotton crops
- Black Urea® field tests with cotton crops have reduced fertiliser use by 5% while increasing yield by 6% to 8% and increasing profit by at least $278 per hectare

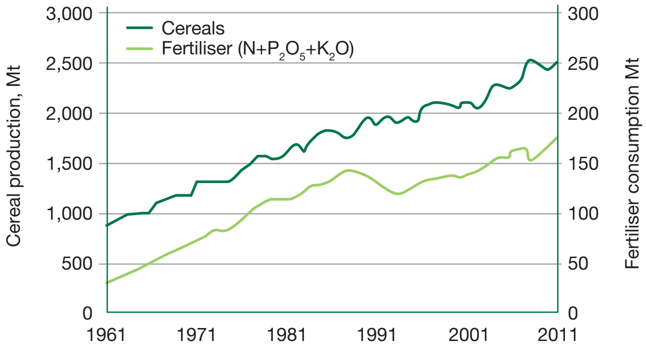
The key role of nitrogen in crop growth and yields

Nitrogen is a critical element in agriculture — it enhances soil fertility, fuels crop growth, and underpins yield and quality.

Nitrogen stimulates root growth and crop development, promotes high protein content, and improves the uptake of other essential plant nutrients.

But (with the exception of legumes) gaseous nitrogen cannot be used directly by plants. It must first be converted to plant-available, reactive forms.

Figure 1: Global cereal production and total fertiliser consumption 1961-2011 (FAO 2012; IFA 2012).



The consequence is that much of modern agriculture is driven by the application of reactive nitrogen to soils in the form of fertiliser, manure and biosolids.

The benefit to crop growth, yield and quality is undeniable.

Around the world, increased use of fertiliser in agricultural crops has dramatically boosted production per unit area, increasing the total supply of food as well as contributing to the quality of food and its content of essential trace elements.

For example, from 1961 to 2008, global cereal production grew from 900 to 2,500 Mt (Figure 1). Much of the growth was due to the increase in world fertiliser use from 30 to over 150 Mt. Without fertiliser use, world cereal production would be halved.

Nitrogen is a significant input cost, yet much goes to waste

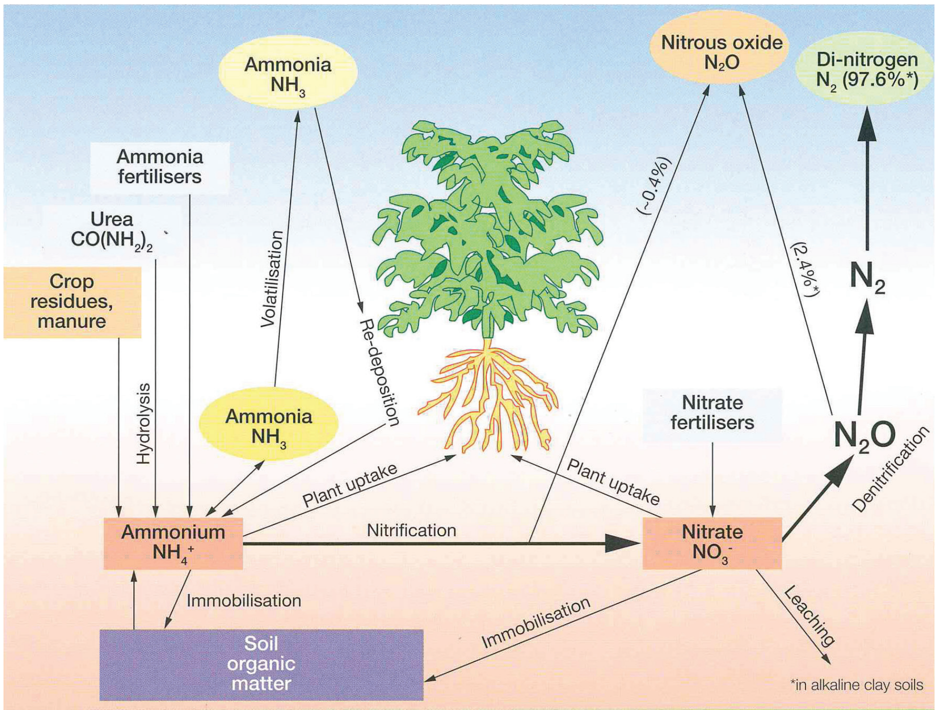
However, nitrogen is also one of the most expensive nutrients to supply to crops, and commercial fertilisers represent a significant portion of the cost of crop production.

Compounding the cost is the fact that not all the nitrogen that granular urea fertiliser delivers actually reaches the crops.

In the field, it's been observed that around 40% of the nitrogen released by fertiliser reaches crops. That's significantly under efficiency levels of up to 90% that have been recorded in well-managed research plots.

Low nitrogen-use efficiency is due to a number of inevitable losses through:

1. Nitrification/denitrification
2. NH3 volatilization
3. NO3 leaching
4. Immobilization of nitrogen in soil organic matter
5. Runoff/erosion of particulate matter



Nitrogen cycles through air, soil and water in various chemical forms. Nitrogen is vulnerable to losses from nitrification, denitrification, breakdown of urea into nitrogen gas, leaching and erosion.

The statistics on nitrogen losses from granular urea fertilisers

One study that analysed Ammonia volatisation and leaching from granular, uncoated urea fertilisers in sugarcane farming concluded that only 33% of the nitrogen was taken-up by the crop when the urea was buried under sugarcane trash.

When it was left on the surface, emulating the minimum tillage policies now adopted by many farmers, the resultant nitrogen uptake was even poorer — dropping to only 18%.

However, evidence does show that changes to soil moisture conditions, rainfall and climatic conditions do affect the size of nitrogen losses to the environment.

Another field study of granular, uncoated urea used gas sampling to determine that losses through volatisation alone ran as high 39.9% during Spring, while dropping to as little as 3.1% in Autumn. Average volatisation over the entire 10 field trials was 22.4% — the study did not account for other forms of leachage and run-off.

Gaseous losses of nitrogen from soils as nitrous oxide through nitrfification and denitrification processes is often less than two to eight pounds per acre in humid regions and under one to two pounds per acre in less humid regions.

While this loss is globally important (nitrious oxide is an important greenhouse gas), it may have small economic significance for farmers compared to the more significant losses that occur through nitrate leaching and ammonia volatisation.

The cost to the environment and to farmers

Nitrate leaching and drainage are the more common avenues of nitrogen loss. In humid, high-rainfall environments, these losses can range from 10 to 40kg of nitrogen per hectare per year for annual crop systems.

This wastage costs farmers dearly. Either they forgo output, or they make it up through buying and applying additional fertiliser to make up for the natural inefficiency of urea and the losses throughout the system.

Leaching and run-off is also costly to the environment. NO3 can seep into groundwater and drinking water supplies, raising water treatment costs for local government. And in waterways, increased loading of nitrogen-based nutrients also plays a role in eutrophication — a process that contributes to ecological and resource degradation.

For example, urea is increasingly proving a component of the nitrogenous nutrition that drives some harmful algal bloom (HAB) species. The global increase from 1970 to 2000 in documented incidences of paralytic shellfish poisoning, caused by several HAB species, is similar to the global increase in urea use over the same three decades. The trend toward global urea use is expected to continue, with the potential for increasing pollution of sensitive coastal waters around the world.

Why normal uncoated urea is highly inefficient

A large part of the problem is the uncoated composition of granular urea granules or prills.

When farmers apply urea to their crops, the fertiliser granules immediately begin to dissolve in the presence of moisture. This occurs rapidly, and opens up great potential for loss of nitrogen nutrients to the environment through volatisation and leaching.

This volatility can vary greatly according to soil temperature and pH. As the tables below show, warmer temperatures increase volatisation rates rapidly, as does an increase in the alkalinity of the soil.

Table 1: Percent of surface-added urea volatilized as ammonia at different temperatures and days on the surface

Data abstracted from curves in SSSP 24, pages 87-90, 1960. Urea was added on a silt loam soil at 100 lbs N.

	Temperature — Fahrenheit			
Days	45 degrees F	60 degrees F	75 degrees F	90 degrees F
0	0	0	0	0
2	0	0	1	2
4	2	2	4	5
6	5	6	7	10
8	5	7	12	19
10	6	10	14	20

Table 2: Percent of surface-added urea volatilized as ammonia at various soil pH levels and days on the surface

Data abstracted from curves in SSSP 24, pages 87-90, 1960. Urea was added on a silt loam soil at 100 lbs N.

	Soil pH					
Days	5.0	5.5	6.0	6.5	7.0	7.5
0	0	0	0	0	0	0
2	0	0	0	0	1	5
4	1	2	5	10	18	20
6	4	5	7	11	23	30
8	8	9	12	18	30	33
10	8	10	13	22	40	44

Black Urea® — a more efficient urea-based fertiliser

Black Urea® is specially formulated to reduce this wastage, so more nitrogen reaches your crops — up to 30% more than with uncoated urea. A unique carbon coating cuts fertiliser wastage and improves the efficiency of nitrogen and phosphorus uptake by crops — ultimately delivering growers greater value-for-money.

Once sown, it is the hard, exterior coating that first melts into the soil underneath or around the granule (depending on the application method), creating a blanket of a variety of carbon products which have an enormous surface area of negative charges.

Then, as the urea in the granule dissolves into positively charged ammonium, those positively charged molecules are attracted and attach to the soup of carbon elements. This is what stabilises the nitrogen within the soil and controls its release.

The natural biological action of nitrifying bacteria then gradually changes the Ammonium to plant-available forms of nitrogen that crops can use.

With coated products, the more stable complex:

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

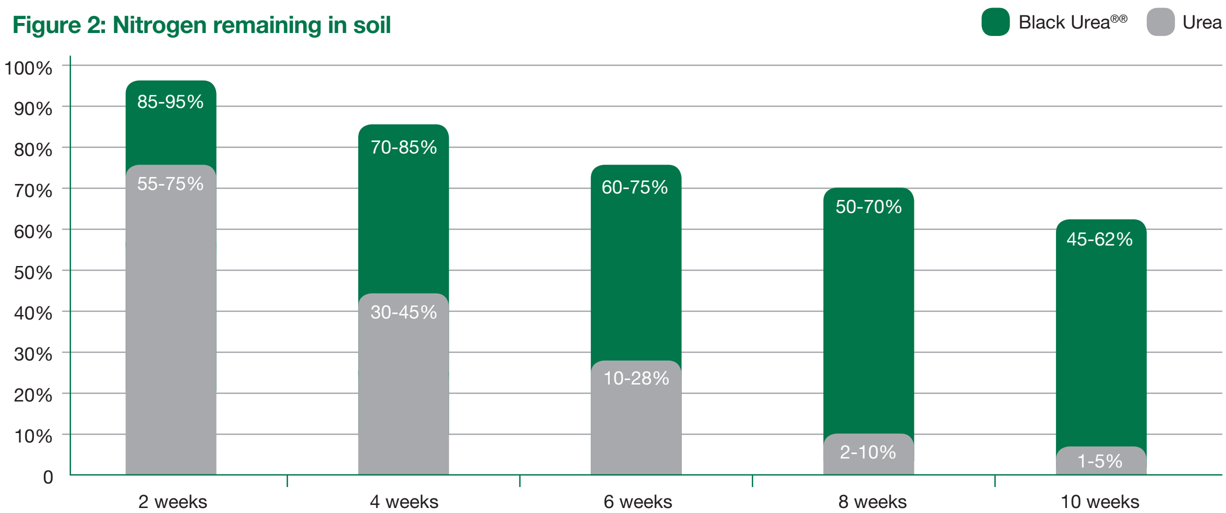
Black Urea® experiences lower nitrogen losses compared to uncoated granulated urea

Agronomist John Ferguson tested Black Urea® against normal granulated urea in 10 plot trials in order to measure the level of nitrogen losses from each over a period of 10 weeks.

In doing so, Ferguson simulated five different soil moisture conditions, ranging from low moisture (almost dry), to very high moisture and then recorded soil nitrogen levels every two weeks. In every case, the measured nitrogen losses from Black Urea® were significantly less than those from standard uncoated granulated urea.

This offers the opportunity for farmers to improve nitrogen use efficiency, with the subsequent benefits to yield and profit.

Figure 2: Nitrogen remaining in soil



Minimum % of nitrogen remaining in the soil of five plots of different moisture ratings, from low to very high.

The importance of organic carbon and nitrogen bio-catalysts

Organic carbon is essential to soil fertility — it provides food for microbes and earthworms, and is critical for binding and processing the nutrients that fuel crop growth, including nitrogen.

The amount of carbon in soils varies from about 0.2 percent in sandy soils to more than 20% in wetlands and bogs.

Conventional ploughing combined with continuous plantings of a single crop results in organic carbon losses of between 0.1 and 0.4 tons per hectare per year. A shift to crop rotation and the use of cover crops cuts those losses to a range of 0.03 to 0.06 tons. Under zero till conditions, continuous cropping provides a gain of 0.3 to 0.6 tons, and with crop rotation these figures can double to a range of 0.6 to 1.3 tons.

Cultivation has depleted the amount of organic carbon in agricultural soils by about half, but controlled-release urea is coated or encapsulated with nutrients to help combat low-soil fertility.

These products released nitrogen gradually to match the pattern of plant uptake over a defined period.

This reduces losses to the environment through volatisation and leaching, and improves plant nitrogen use efficiency.

These products are already widely used on turf and horticultural crops but until now their use on agricultural crops has been constrained by cost.

Black Urea® employs organic carbon for controlled release

Of course, the use of bio-stimulants for enhancing efficiency of fertilisers has a chequered history with many field demonstrations leaving economic validation wanting.

Humic acid alone is insufficient, and urease inhibitors can actually have long-term negative effects on soil fertility by depressing the natural nitrogen cycle.

Black Urea®, on the other hand, is a enhance efficient fertiliser (EEF) with a proprietary carbon bio-coating that includes organic acids, bio-stimulants, surfactants, vitamins and minerals.

Stabilising technologies maintain coating integrity and control the decay of the packet that bonds with the nutrient to form an organic complex.

Black Urea® also includes a small amount of humic acid to provide exchange capacity. Only humic compounds with a specific ratio of functional groups and a very high surface area are effective in these trace amounts. No humic compound alone is capable of increasing the metabolic rate necessary to target soil microbes by itself, only the complex of can do this.

However, its price closer to conventional granulated urea fertilisers — this makes it much more economically attractive to growers.

Commercial field trials of Black Urea® on cotton crops

Commercial field trials of Black Urea® on cotton crops bear out expectations — compared to normal granulated urea it delivers the same or better yields while using less fertiliser.

In summary:

- Leachage and volatisation is reduced and nitrogen use efficiency maximised
- Yield increased by 8.83% in one northern New South Wales trial and net profit increased by $538 per hectare
- Yield increased by 6.32% in another trial in southern Queensland, for an increase in net profit of $278 per hectare.

Cotton trial — Southern Queensland

The trial used an irrigated cotton crop in Southern-Queensland at Talwood to compare the yield and quality of Black Urea® against that of white urea in side-by-side plots in the same field.

Both Black Urea® and white granular urea were pre-plant applied at the same time with the farmer's existing machinery. White urea was applied at a normal rate (410kg/ha in this instance), while Black Urea® was applied at a rate of 95% of that (i.e.: at 390kh/ha).

All other crop management decisions were maintained constant.

On average, Black Urea® yielded 0.59 bales per hectare more than the White urea — 9.93 bales per hectare compared to 9.34 bales per hectare. At a price of $500 per hectare, and even factoring that Black Urea® still costs marginally more (an extra $22 per hectare), the Black Urea® trial delivered the farmer an extra $278 per hectare.

Cotton trial — Northern New South Wales

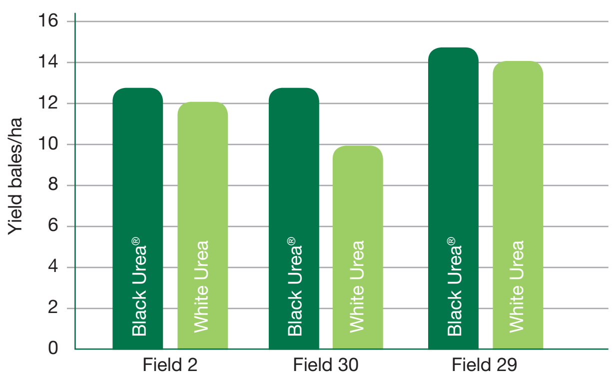
As in the southern Queensland trial, this trial also compared the efficacy of Black Urea® (compared to white, granular urea) when pre-planted at a 95% rate — 390kg/ha versus 410kg/ha.

This trial used three fields of 2.4 hectares.

Apart from the different urea application rates, all other crop management decisions were kept the same.

On average, Black Urea® delivered significantly higher yields — an extra 1.12 bales per hectare more than the white urea. The maximum, in field number 30, it was 2.42 more bales per hectare. The minimum improvement was 0.33 bales per hectare in field number 2.

Figure 3: Yield Comparisons between Field Treatments



Again, at a price of $500 per hectare, and factoring the increased unit price of Black Urea®, the grower still made on average an extra $538 per hectare.

Further experimental nitrogen bio-catalyst research

The success of Black Urea® has also prompted further research into using carbon bio-catalysts to improve the production economics of flood irrigation agriculture in Queensland.

Anhydrous ammonia is a toxic gas applied to soil under temperature-controlled pressure. It's common to use this as a fertiliser used in flood irrigation systems.

Unfortunately, this use has a negative effect on the soil organic matter and biota that are critical to high nitrogen use efficiency.

Research has found that mixing a modified humate base and bio-catalysts with anhydrous ammonia stabilises and stores the ammonia. This reduces the impact on soil organic matter and cuts wastage of fertiliser nitrogen.

Current two-year commercial-scale demonstrations in irrigated cotton have produced equivalent yields to usual practice even when reducing application rates by an additional 20%. This has reduced the cost of nitrogen per production unit (bales of cotton lint) by more than 15%.

Maximising yield while minimising input cost — short-term and long-term

Lack of reactive nitrogen in the agro-ecosystem leads to soil fertility decline, low yields and crop protein content, depleted soil organic matter, soil erosion and, in extreme cases, desertification.

To remedy this requires a short-term, and a long-term strategy.

In the near-term, to obtain the most profitable crop, growers need to "feed the plant when it needs it".

This means determining what nutrients the crop requires, then ensuring an adequate supply — preferably through the root system.

The minimum must be crop replacement, then preferably 10-15% in excess to counter natural losses in the system. Priority is nitrogen, as well as potassium, calcium, phosphorous and sulphur. However traces elements cannot be ignored.

Timing of nutrient application is crucial. A good rule of thumb is to follow a "little more often" approach where practical.

Ongoing test strips are critical to maintaining a tight control of budget and input costs.

This provides the turning point for improving long-term production.

In the long-term, it's all about improving and maintaining soil fertility.

Carbon is the primary focus. Organic carbon is significantly deficient in millions of hectares of arable land around the world, leading to sub-optimal yields and consequent effects on profit.

Focusing on improving soil carbon quality often delivers the biggest and most-immediate benefit to soil fertility, and sets a platform for long-term sustainability.

Our target soil organic carbon is 2.5-3% in balance 12:1 with nitrogen.

Long-term improvements deliver further reductions in farm inputs, better disease and pest control, use less water, diesel, and deliver improved crop quality.

CONTACT US TO USE BLACK UREA® ON YOUR CROPS

We hope you've found this whitepaper both interesting and useful.

If you'd like to learn even more about Black Urea®, or explore the potential for a trial of Black Urea® on your crops, so you can see for yourself how it measures up — both in terms of reduced inputs, and increased yields and profits — contact us contact us at - **service@advancednutrients.com.au** or call - **1800 244 009.**

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About Advanced Nutrients

Advanced Nutrients is a leader in the development of innovative, environmentally Enhanced Efficient Fertilisers, Bio-stimulants, Irrigation Line Cleaning & Water Conditioning products which cost less and deliver more.
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