Enhanced Fertilizer Efficiency – Fertilizer Products

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Summary

Innovations in fertilizer technology have provided farmers with new options to both improve fertilizer use efficiency and increase potential profits based on the cost of the technology. It is critical that farmers and advisors understand what potential gains these technologies can provide as some support improvements specific to particular environments or crop management systems.

- Controlled release, or coated, fertilizer technology has been shown to provide a significant improvement in N uptake by crops, and reduce N losses, in high moisture environments. Little to no advantage has been captured from these technologies when used in dryland farming, or when surface broadcast without abundant rainfall to move them into the soil.
- Urease inhibitors are likely provide the best support to minimize N volatilization with surface broadcast urea. The effect is temporary, providing about 10 days of stabilization prior to breakdown. However, this can provide improved safety to a farmer when surface applying urea ahead of forecast rainfall.
- Nitrification inhibitors can be of value in higher rainfall areas where retaining N in the ammonium form could reduce leaching as well as denitrification.
- Managing low rates of micronutrients can be a major challenge, given the large number of formulations available. Selecting a formulation which has been shown to work, and following the application guidelines and timing carefully, can help in optimizing the crop response.

Nitrogen Fertilizer Product Technologies

Controlled Release Urea – there is considerable interest in North America with the new controlled release urea (CRU) released by Agrium into the broadacre crop market. The CRU is a plastic (polymer) coating on urea which, based on temperature and available water supply, regulates the release of urea from the product. This product has a long history, starting originally in the golf course turf and vegetable market, where long-term N release has great economic value. Further refinement of the coating thickness for field crops has provided products which release their N after 30-60 days post-application. Even longer release profiles are available, but the cost usually limits these products to the turf and horticulture market. The principle market for these 30-60 day products has been areas where high rainfall leads to leaching losses of N, and for crops which have a long, or late season, N demand. The product has been shown to work very well, reducing N losses and maintaining or increasing current yields with reduced N rates relative to untreated urea. In most instances the company shows increased yields at similar N rates, indicating more of the N ends up in the crop versus being lost by leaching. Part of the interest with these coatings in rainfed systems is that the when rain does fall, N is dosed when roots grow and the crop can utilize the fertilizer – theory keeping N supply synchronized with plant demand.

CRU has also been shown to work very well when seedrow applied with sensitive crops such as canola, the damage from this application is almost completely eliminated. While this is not a common practice, there are many farmers in western Canada using direct seeding systems with limited options for N application and so cannot use bare urea close to the seed because it has the potential to cause significant crop establishment damage.

As far as the small print on this product, IPNI has learned that when you coat a fertilizer with a plastic it floats, and this has limited its usefulness in double cropped rice trials in southern China. The product has to be incorporated, as even a heavy rainfall event will literally "float away" the urea granules, resulting in uneven distribution, or worse yet, transported off the field. Where this product has not been shown to have much benefit is where N is in-soil banded (side or midrow banded) at seeding (no-till systems), in semi-arid regions where a lack of precipitation means the product does not release from the plastic coating (remember, the urea does not move into the soil with precipitation as it is contained in the plastic coat). While small benefits are often recorded, it is more common to have similar effects with bare urea. Surface broadcasting this product on to a no-till wheat stand would work only if there is sufficient rainfall, or better yet irrigation, to ensure that when the urea releases from the granule it is moved into the soil.

Urease Inhibitors – the product nBTPT (Agrotain®) (Green Urea™ in Australia) is an effective urease inhibitor, helping those growers extend the period which surface applied urea is free from volatilization ammonia losses. The urease enzyme in soil and crop residues converts urea to ammonia, so slowing this change reduces the ammonia N loss by volatilization. Most trials have shown that use of Agrotain at recommended rates will prevent ammonia losses with surface applied urea for 10-13 days (Turner et al., 2009). This has proven very effective when urea must be surface applied in no-till fields, where accumulated crop residues enhance the potential for ammonia volatilization. The Agrotain® is applied at the dealership and has a limited storage life. Achieving adequate coverage of the product on urea granules enhances the effectiveness. An advantage of the Agrotain® treated urea is that it remains mobile and will move into the soil when rain is received.

The advantage of urease inhibitors is specific, in that the inhibition lasts for only 10-13 days. After this time period the risk of ammonia volatilization increases at a rate which is similar to untreated urea. However, this protection can assist where large areas are spread with broadcast urea, which restricts the area that can be covered immediately prior to rain.

Nitrification inhibitors – the second conversion from urea hydrolysis is the conversion of evolved ammonium to plant available nitrate. This process can be slowed using a nitrification inhibitor and DMPP (Entec®) is available in Australia. Edmeades (2004) concluded that the impact of nitrification inhibitors is likely most on where nitrate leaching is probable, on friable soils under high rainfall. Improved crop yields under these circumstances then depends on soil N status, where the conservation of this extra N will have an impact if soil N is low. That author also concluded that the impact of nitrification inhibitors would be low on heavy clays with poor drainage. Entec® Urea would therefore be useful at sowing (ie in furrow) rather than topdressed.

Table 1. Considerations for various strategies for the application of N to field crops from UM00023.

Treatment/Strategy	Equipment	Added Operating Cost	Sowing Efficiency	Extra Product Cost
Urea Deep banded	Seeder with deep banding	nil	Base comparison	Nil
Urea Pre spread	Seeder with deep banding	Extra operation pre-sowing	Less N handled at sowing	Nil
Urea + Nitrification Inhibitor Deep banded	Seeder with deep banding	Nil extra operating	Same as base	Supplement
UAN Deep banded	Seeder with fluid applicator	Nil extra operating, plus equipment	Same as base	UAN rather than urea
Urea Top-dressed @GS30	Ground or air spreader	One top dressing	Less N handled at sowing	Nil
Urea + Urease Inhibitor Top-dressed @GS30	Ground or air spreader	One top dressing	Less N handled at sowing	Supplement
UAN Top-dressed @ GS30	Ground spraying	Done with crop protection application	Less N handled at sowing	UAN rather than urea

Under Australian cropping conditions, comparisons between various N sources can give small improvements in nutrient use efficiency, but there can also be some management efficiency benefits, which are summarized in Table 1, which is taken from a UM00023 report (Norton et al. 2008a).

Phosphate Fertilizer Product Technology

Avail – is a product which uses Nutrisphere technology marketed by the USA company Specialty Fertilizer Products (*http://www.specialtyfertilizer.com*). It is either sprayed on to dry fertilizer P granules, or added to liquid P fertilizer. The product is made up of di-carboxylic acids (maleic and itaconic), which they claim to provide a strong negative charge coating around the P, decreasing the precipitation of the P by calcium, magnesium, iron and aluminum in soils. As a result the P remains available for plant uptake longer, increasing the overall plant recovery of applied P fertilizer.

As with all new products introduced to the market, growers need to see data from similar environments when evaluating the product. There is considerable variability in the data available on the product from both the company results and those collected by independent researchers. Results evaluating wheat biomass production and P uptake in Western Australia (Damon et al. 2009) showed that addition of Avail improved yield and uptake at the lowest P rate (6 kg P/ha). At higher P rates (12 and 18 kg P/ha) there was no difference between treated and untreated P fertilizer. These results are similar to those obtained in western Canada where there have been few responses to Avail. There appears to be a greater chance of capturing a response with high yielding production systems, especially high yielding corn and rice and that is where the company shows better responses.

This product is currently under evaluation in Victoria and may be of value especially on alkaline soils. Application as an in-furrow liquid is one additional area for consideration.

Secondary and Micronutrient Fertilizer Technology

MicroEssentials – the MicroEssentials S-10, S-15 and SZ granular fertilizer were developed and are marketed by the Mosaic Company in Australia (www.mosaicco.com). All three products were developed by incorporating sulphur (S) alone, or S and zinc (Zn), into the mono-ammonium phosphate (MAP) granules. By incorporating these nutrients, low rates of Zn and S are essentially applied at a high rate across the field. Products are sold as 12-40-0-10, 13-33-0-15 and 12-40-0-10-1Zn. The S-10 and S-15 products were developed to allow sufficient S addition where crop demand for S could be met with low rate application, such as canola. Similarly, the Zn addition with the S in MAP provided a much lower rate of application where the deficiency existed.

Table 2. Summary of P source experiments in the Wimmera and Mallee 2005-2007, showing situations where particular P sources gave better yields than MAP. Values in parentheses after the product are the percentage yield increase over MAP at that site/year.

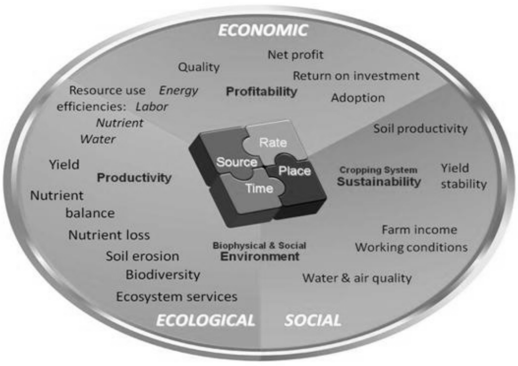
	Year	**P Response**	**Best Products (>MAP)**
Wimmera	2005	No (Marnoo)	No differences
	2006	Yes +10% (Kalkee) (but droughted – low yields)	LiquidAP (+15%), APP (+15%)
	2007	Yes +7% (Kalkee)	APP (+8%), Humic Acid Treated MAP (+8%)
Mallee	2005	Yes +5% (Sealake)	AMS (+14%), MES10 (+9%), APP (+5%)
	2006	Yes +11% (Hopetoun)	Humic Acid Treated TSP (+35%), Composted Rock Phosphate (+25%), Humic Acid Treated MAP (+19%)
	2007	Yes +10% (Walpeup)	Nothing
Western District	2005	Yes + 34% (Yalla-y-poora)	APP (+17%), MES10 (+9%)
	2006	Yes (+12%) Yalla-y-poora	Nothing
	2007	Yes (+33%) Mininera	Nothing

Field research data from the GRDC project UM00023 showed that the S fortified P source always provided a response equal to MAP and at 2 of 9 sites was significantly better, irrespective of the effect of the additional S (Table 2). The agronomic benefits of the MES series are under test at the moment in Australia and some other S fortified products are being evaluated by Incitec Pivot. The value of these alternative sources should be evaluated as an economic decision rather than just agronomically.

Given the fixed concentration of Zn and S in the MAP, the total product rate of application can be modified to account for the desired S or Zn required. The greatest advantage of these products is handling for the farmer, allowing 3-4 nutrients to be delivered in one product. Some of the multi-nutrient fertilizers, either blends or mixtures could provide improved crop nutrition by either co-location of nutrients improving nutrient balance, improved root zone chemistry or by some other mechanism.

4R Nutrient Stewardship

In an effort to address the rise in concerns related to fertilizers in the environment, IPNI has spent considerable time evaluating approaches to optimizing nutrient and fertilizer use practices by farmers. The outcome of this process was the 4R Nutrient Stewardship concept (*www.ipni.net/4r*). The 4Rs stand for Right source of fertilizer, Right rate of fertilizer, Right timing of fertilizer application, and Right placement of fertilizer to optimize crop response. IPNI acknowledges that to be "right" this nutrient stewardship approach must offer balanced support of the economic, social and environmental goals as defined by users (farmers, advisors, industry, government, etc.). Further related to the 4Rs concept is the development of nutrient Best Management Practices (BMPs). Unlike the 4R component principles, BMPs are actions which vary from area to area based on the crop production system – BMPs are site-specific. While every nutrient application involves all of the 4R components, all nutrient BMPs link to one or more of the 4R components.



Examples of the development of site-specific nutrient BMPs have been developed by IPNI for a number of cropping systems and environments in North America (*www.ipni.net/4r*). These examples are very specific in how all nutrient sources are managed and how nutrient management decisions are made for agronomic and economic responses. At the same time we attempted to ensure we were also considering the greater social, economic and environmental goals. This process of developing site-specific BMPs was started to address the growing concern that a set of appropriate practices was not documented for many of the cropping systems in North America. It was decided that if governments were considering regulating crop production practices in various regions and watersheds in the USA, it was appropriate for us to package a set of best practices which we felt most appropriately addressed the issue of nutrients.

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