

Look to the sky for nitrogen, not its price

By Richard May, Agricultural Energy

Successful farming is often all about choosing the right options. We need to simultaneously minimise a host of crop production and marketing risks, evaluate a vast range of management options while all the while, staying profitable.

On the production front, rapidly escalating fertiliser, chemical and other input prices are making it very difficult to put profitable budgets together. The price of nitrogen fertiliser in particular is now very high (Table 1) in the face of a huge world-wide demand for hydrocarbons.

But a new, and relatively inexpensive nitrogen bio-fertiliser product, offers growers another option to consider for crop nutrition – and we need to look to the sky to make it work.

Looking outside the square

Biological processes can be a significant source of natural N, but many soil management systems or geographic locations are not always conducive to high production and retention of atmospheric-derived N in the soil.

Air/atmosphere is the most critical determinant of life in the paddock. And elemental (or atmospheric) nitrogen is the largest single constituent of the Earth's atmosphere at around 78 per cent of its volume. This means that there is around 78,000 tonnes per hectare of N sitting over every paddock – how can we tap into more of this 'free' N?

Given favourable conditions, and the right bacteria, considerable quantities of atmospheric N can be 'fixed' for use by the soil and plant. But so-called best-practice agriculture has tended to tie production systems into a dependency on synthetic N to achieve high production.

Research results here and internationally, should encourage us to think outside



Replicated barley trials in 2007 at Horsham, Victoria, compared the bio-fertiliser to several applications of complex foliar nutrition. The harvested yield results were almost identical.

the square. For example, Brazilian sugarcane research shows that some of the best producing varieties in Brazil have little demand for synthetic nitrogen fertiliser. An effective association has developed with endophytic nitrogen-fixing bacteria – that is, a beneficial bacteria growing within the sugarcane plant.

What implications might this type of research and technology have for non-leguminous broadacre – and other crops in Australia?

Worldwide research

There is considerable global interest in the potential of endophytic diazotrophs – bacteria able to fix atmospheric nitrogen into a useable form for plants – as a biological N alternative to synthetic N. This has enormous implications for non-legume crops.

In Australia, private, university and CSIRO research programs have been investigating this potential in high N-demand crops, like sugarcane, and for other crops.

A technological breakthrough

A decade of research by Queensland-based company Mapleton Agri BioTec, has produced a bio-fertiliser which can be applied to both dicotyledons (a flowering plant with two cotyledons in the embryo, such as bean crops) and monocotyledons (plants with one cotyledon, for example most grasses, wheat, barley etc). The technology is called TwinN.

It consists of several strains of high yielding nitrogen-fixing microbes (bacteria) functioning in two pathways. The bacteria colonise as endophytes within the vascular system of a plant and in the plant's root zone (the rhizosphere).

The breakthrough included the ability to multiply and freeze-dry a suite of bacteria in large numbers without killing them. N-fixing bacteria can now be applied to all crops using current application techniques such as boom, drip, overhead sprays or plane.

Biological innovation

The main pathways to achieve biological N for cereals and other non-leguminous plants have been via legume crops, mineralised crop residues or from properly composted material.

Trials are indicating that the new bio-fertiliser, with its suite of bacteria, can be applied to non-leguminous crops to transform atmospheric N into plant (or rhizosphere) available form. The plant itself controls the rate of N production.

TABLE 1: The cost of various forms of synthetic nitrogen, ex works Victoria, 2008

Category of N	MAP	DAP	SOA	Urea	Cal Nit	ASN	CAN	UAN
\$ per t/1000 L*	1,100	1,100	330	640	720	465	550	820
\$ per kg/L	1.10	1.10	0.33	0.64	0.72	0.47	0.55	0.82
% N (w/v)	10.0	18.0	20.2	46.0	15.5	26.0	27.0	42.5
\$ per kg unit of N	11.00	6.11	1.63	1.39	4.65	1.79	2.04	1.93

* Cost ex-works Victoria, 24-01-2008

Scope and diversity of application

TwinN technology will not replace synthetic N. But it provides a natural alternative N supply and can be used in conjunction with synthetic N. It can also be used on organic certified crops as an adjunct to humified compost.

In some farmer-driven field trials, TwinN has been compared as a total replacement for synthetic N, with encouraging results. But it is generally recommended that Starter N is applied to a crop followed by the bio-fertiliser when the plant is established – usually in the early tillering stage for broadacre crops.

In broadacre, the product has been applied successfully to wheat, oats, barley, spelt, canola, cotton, sugarcane, ryegrass, mixed pasture, lupins, chickpeas, lucerne and beans.

In horticulture it has been used on potatoes and melons, and on various tree crops including citrus, stone fruit, cherries, olives, apple, macadamia and on vines.

Nitrogen quality

Nitrogen from TwinN is produced in the ammonium and amine form, and does not require further biological conversion. This supports retention of soil carbon, and enhances plant and animal health. It avoids problems associated with nitrate toxicity and losses to atmosphere, denitrification and leaching.

FARM TRIALS

A number of trials using TwinN have been conducted over a diversity of crop types both in Australia and overseas. And many of these trials have been entirely farmer-driven. For example, in 2007 a Lake Grace (WA) farmer trialed the bio-fertiliser in 100 hectare plots of various crops.

For the wheat and canola trials, 60 kg



A closeup of the endophyte bacteria at work in wheat roots. The bacteria has been given a dark stain so it can be seen.

per hectare of DAP was applied as starter fertiliser. In-crop rain was 226 mm. The trials were replicated and the wheat results are shown in Table 2. There was a slight increase in wheat yield, less screenings and a slightly higher grain weight with the TwinN treatment. The product cost of the bio-fertiliser was \$5 per hectare less than the Calcium Ammonium Nitrate (CAN) as the top-up nitrogen source.

TABLE 2: Farm trial comparing Calcium Ammonium Nitrate (CAN) to TwinN as the top-up nitrogen source for wheat, Lake Grace WA, 2007

CAN kg/ha	CAN \$/ha*	TwinN \$/ha	CAN T/ha	TwinN T/ha
50	29	24	2.36	2.46
Screenings %			1.3	0.7
Grain weight			83.0	85.9

*Cost ex-works Fremantle 2007 @ \$580/tonne

Other comparative trials on barley at Lake Grace, using 50 kg per hectare CAN, yielded 200 kg per hectare less than the TwinN treatment; On canola and oaten hay, it was the same yield compared to 100 kg per hectare of CAN; and, On lupins (no fertiliser), although not harvesting the trials due to drought, there was a measurable increase in nodulation with the bio-fertiliser.

More farmer-trials at Lake Grace are planned for the 2008 season.

IN-FIELD USE OF THE TECHNOLOGY

Regeneration of the sterile bio-material takes about three to four hours using rain-water. It can then be mixed with additional water and applied to the field.

The regenerated bacteria can be stored in the fridge for up to three weeks.

Constraints and limitations

TwinN should be applied as a stand-alone treatment. It requires moist conditions on the plant and in the soil for survival of the bacteria. Inoculation takes only two to three hours but desiccating conditions need to be avoided. High humidity is ideal.

The best application time is early morning, late afternoon or at night.

A buffer of three to seven days is recommended between inoculation of TwinN and before applying crop nutrition biocides or other toxins.

Crops stressed from water or nutrient deficiency will not respond the same as healthy, actively growing crops. If significant N is available, plants can limit their requirement for biological N. High appli-

cations of synthetic N can also have a negative affect on endophytic bacteria survival in the soil.

The nitrogenase enzyme reaction (that is, when bacteria activates the conversion of nitrogen to ammonia) of biological N requires the presence of other elements such as molybdenum and iron. Potassium and sulfur also act as catalysts. So well-balanced soil nutrition aids the efficient production of biological N.

Number and timing of applications

In most broadacre crops one application at early tillering is sufficient for the crop cycle. With more intensive crops such as in horticulture, vines or tree crops, two or more applications may be advantageous.

The normal timing for synthetic N applications is a useful guide until more on-farm experience with this bio-fertiliser is gained.

Is the sky the limit?

While the sky might appear to be the only limit on ever-increasing prices for synthetic N, the sky is also home to a largely untapped source of atmospheric nitrogen.

Bio-fertilisers can be a very useful addition to the toolbox of innovations farmers need for an economically and environmentally sustainable farming future.

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CONTINUING RESEARCH

A continuing research program into TwinN at Mapleton Agri BioTec laboratories is supplemented by a number of collaborative research programs. These include Australian research organisations such as:

- Narrabri Cotton Research Station: Comparison to conventional fertilisers.
 - Sydney University: Mechanisms of movement through the plant's vascular system.
 - Apple Institute, Stanthorpe: Control of root disease.
 - BSES Ltd: Sugarcane research.
 - UniQuest (Gatton Qld): Wheat trials.
 - Dalby Agricultural College (Qld): Sorghum.
 - Peracto: Cotton and bananas (in 2008)
- International organisations undertaking collaborative research include the UK Grasslands Institute, Missouri University (US), International Rice Research Institute (Phillipines) and various African-based institutes.