# GRDC PODCAST TRANSCRIPT

**Predicting nitrogen loss: Better data, better decisions**

[00:00:05] **Intro** This is a GRDC podcast.

[00:00:12] **Professor Mike Bell, UQ** The way we've set these field trials up, we have different rates of fertiliser nitrogen, applied as normal conventional urea, and we also have rates of nitrogen applied with urea that's been enriched with the natural isotope of 15N. What we're trying to do in this instance is account for every bit of fertiliser nitrogen, that we've applied in these fields.

[00:00:36] **Darryl Anderson** That's Professor Mike Bell from the University of Queensland. I'm Darryl Anderson and welcome to this GRDC podcast. Fertiliser is the biggest variable input cost in Australian grain growing. It's not news that a fair bit of fertiliser nitrogen never makes it into the crop. The ways it gets lost are also well understood, including as nitrous oxide, a significant greenhouse gas. There's a link to a GRDC podcast all about nitrogen loss pathways in the notes for this one. Recent massive N fertiliser price increases, make it more critical than ever to minimise nitrogen losses, as do global moves to lower emissions. But our data on how much soil nitrogen we can expect to lose under real world circumstances is pretty disconnected and gappy. Mike Bell is leading a GRDC funded research program, including all the mainland state agriculture departments, several universities and the CSIRO, that involves trial sites across the country and it aims to provide the data we lack to predict nitrogen loss. Mike, how big of a problem do we have in terms of losing nitrogen that could otherwise be turned into grain?

[00:01:57] **Professor Mike Bell, UQ** Well, I guess the answer is it depends. It depends on the soils and the seasons and the environmental conditions that you're operating in. But if you look at averages across the industry, we would recover perhaps less than 50% on average of the nitrogen that we applied actually ends up being used by the crops that we apply it to. So that says that there's a significant amount of nitrogen that isn't going in to meet our current crop demands. Now some of that nitrogen is going into the soil nitrogen pools and will be available in subsequent seasons. There's another significant component that's being lost to the environment via a variety of pathways, and it's those losses that we're interested in trying to minimise. At the same time as we try and maximise the recovery and use by the crop.

[00:02:50] **Darryl Anderson** Just to summarise, what are the ways that we lose nitrogen from our soil?

[00:02:55] **Professor Mike Bell, UQ** We can lose nitrogen in two ways. We can lose it as a gas and there's two main processes that it can be lost as a gas, one is as ammonia through the process of volatilisation. That typically occurs from nitrogen applied onto the soil surface, so not buried in the soil but applied onto the soil surface. The other process is denitrification, now that's typically occurs when you've got excess nitrate nitrogen in soil and you end up with low oxygen availability and microbes competing for oxygen that they remove from nitrate. So those are the two main gas loss pathways. The other loss pathways are via water and so either in runoff, so you get stuff leaving the field in runoff dissolved nitrogen or leaching through the soil profile as nitrate and getting below the depth of the root zone.

[00:03:51] **Darryl Anderson** We don't want to lose nitrogen because that's lost production potentially. It's an input, we want to produce grain with it. But one of those pathways, the denitrification pathway, can result in the emission of nitrous oxide into the atmosphere, which is also a greenhouse emission.

[00:04:09] **Professor Mike Bell, UQ** Nitrous oxide is a very potent greenhouse gas, so it's got about 300 times the global warming potential, molecule for molecule as CO2 does. So whilst the nitrous oxide emissions people often say emission factors of say between 1 and 2% of fertiliser nitrogen, is nitrous oxide depending on the industry. And I've often talked to growers and they say, ah, I spill more than that when I'm filling my fertiliser rig and they're quite right. But when you start multiplying that by that 300 multiplier, you end up with emissions that often dominate the entire greenhouse signature for a farming operation, just through very small emissions of nitrous oxide. So in addition to that, of course you're manufacturing more fertiliser to replace it. I guess the point to remember about denitrification though, is that yep, nitrous oxide is a greenhouse gas, it's very significant, but particularly in clay soils, it's not the main product of denitrification. The main product of denitrification is often N2 or dinitrogen, which our atmosphere is 80% of already, very hard to measure. But if you're losing, say, two kilos as nitrous oxide, you might be losing another 30 to 50 kilos as N2. And so that is where it really hits your back pocket in terms of your fertiliser budget.

[00:05:35] **Darryl Anderson** So we do know about the nitrogen cycle. You've just explained it very well. Why don't we know enough about it, to do enough, to reduce our loss of nitrogen from our systems?

[00:05:46] **Professor Mike Bell, UQ** I think that the issue is that we haven't done enough, across enough systems, in enough detail, to be able to be accurate with this sort of stuff. So, for example, denitrification losses, if we have a wet season, people automatically assume that we've lost nitrogen from denitrification. We may have, we may not have? How can people predict how much nitrogen they've lost from a given wet event? We haven't got the tools to be able to do that with any accuracy at the moment. The same sort of thing with volatilisation. I mean, there's been a fair bit of work done on clay soils looking at potential volatilisation losses, but very little done on lighter textured soils where the risk is potentially even greater and we just don't have much in the way of figures for it, so a lot of our nitrogen work has looked at crop responses to applied nitrogen. It hasn't looked at that loss factor and so, we've measured a response, we've said, okay, this is the sort of rate of nitrogen that we need. We don't really know enough about the nitrogen that we didn't recover and where that ended up. And so, you know, you've got a situation where people apply nitrogen for a season where they didn't use it. How much do they count on that for next year? We can't predict that with any real confidence at this stage. And so, as we get into systems that are more reliant on fertilisers, we really need to tie these details down because they're the going to be the things that make or break the performance of our cropping systems.

[00:07:24] **Darryl Anderson** Hence the national project that you're heading up. Tell me about that and how it's structured?

[00:07:29] **Professor Mike Bell, UQ** So this represents a partnership by most of the State Departments and a number of the universities across Australia. We've developed a research program that's got 12 dryland field sites and another three irrigated sites on major soil types and representative cropping systems across the country. We're all using very similar approaches to fertiliser management to, to measuring losses, to measuring crop recovery, to measuring residual value, not from one season to the next, but across three consecutive growing seasons. So this is a real attempt to get detailed measurements across the country in the major soil types and cropping systems all gathered using very similar techniques. So we can get a decent snapshot of what's happening in the Australian grains industry with respect to nitrogen fertiliser and in some instances where extending that to look at legume nitrogen in those systems as well.

[00:08:31] **Darryl Anderson** The project began in the middle of 2022. How long does it run and how many crop cycles?

[00:08:36] **Professor Mike Bell, UQ** The project commenced in mid 2022. We're actually running three consecutive either summer or winter crop seasons, so the field program has just started in the north. So sites on the Darling Downs run by the Queensland Department of Agriculture and Fisheries and here at the University of Queensland at Gatton. So we're both looking at summer sorghum production. In fact, all other sites are looking at winter crop production. So from Tamworth south and west I guess across the industry are looking at this coming winter crop season, this being their first season. So in this intervening 12 months we've been refining some of the methods to measure volatilisation and Graeme Schwenke and New South Wales DPI has been looking at different methods for capturing gases from volatilisation. The engineers at QUT, a rapidly manufacturing semi-automatic gas chamber systems for capturing denitrification losses, so we're all using the same kit. Graeme's manufacturing similar stuff from New South Wales for nationally. We've ordered an inordinately large or expensive amount of N15 which has been sent to us here in Australia.

[00:09:51] **Darryl Anderson** What's N15 though?

[00:09:53] **Professor Mike Bell, UQ** Okay, so that's a naturally occurring, a stable isotope of nitrogen. Normal nitrogen is N14, so this is a naturally occurring, stable isotope that we enrich our fertilisers with so we can track the fate of that isotope which is linked to the fate of the fertiliser, so that's...

[00:10:10] **Darryl Anderson** Nitrogen with a signature?

[00:10:12] **Professor Mike Bell, UQ** Nitrogen with a signature essentially, and a non-radioactive one, which is even better for the guys handling it! So we bought 8 kilos of concentrated, enriched N15 from a manufacturer. We bought it into the country. We've on forwarded a vast majority of that to the US with some collaborators there who are diluting that and pelleting it, so that it comes out as urea granules very similar to what we're using in our field agriculture programs. So we've basically created a, an enriched urea product that into all intents and purposes will behave like a conventional urea granule but we can track it. So there's been a lot of stuff going on in the background to try and get ready for the big winter season. We're a little bit in advance with this summer crop, so the program finishes in mid 2026, but we will have three winter crop seasons or three summer crop seasons if were here in the north by the end of that activity.

[00:11:09] **Darryl Anderson** Dr. David Lester from Queensland Department of Agriculture and Fisheries is leading the Queensland dry land component of the research.

[00:11:18] **Dr David Lester, QDAF** Australia is a very diverse landscape and so the climatic and soil and crop conditions across that cannot be represented by one location. Here in eastern Queensland, south-eastern Queensland, where we're based in Toowoomba, the heartland of grain growing in Queensland extends between Miles and Mungindi. We have high clay content, variable climates, stored moisture, climatic systems, nothing like the deep sands or the variety of soils that exist across South Australia and Western Australia so, it's also to do with when it rains, we have typically summer dominant rainfalls, whereas southern and western Australia have winter dominant patterns. So, wheat is still the biggest cereal crop that's grown in Queensland. But this research is going to focus on sorghum because it's a high yielding crop in the eastern areas, we should be averaging seven tonnes to the hectare for a lot of the eastern Darling Downs and down into north-eastern New South Wales on the Liverpool Plains, probably growers would be aiming to be higher than that. So it's high production systems and so that means we need nitrogen in those environments to keep those systems reaching their yield potentials. So it's part of the national footprint. It's important that we capture what summer crop in Australia looks like as far as its nitrogen dynamic.

[00:12:38] **Darryl Anderson** How much better do you think growers in the area that you're representing, as it were, can be at keeping the nitrogen that they apply and the keeping the nitrogen that they work up through the rotations in their system, so it's actually used by their crops?

[00:12:54] **Dr David Lester, QDAF** It's a very good question, Darryl. A lot of that is both the focus of this research because the use of, as Mike talked about, we're using stable isotope. So it's very definitive in this is the fertiliser that I applied to that piece of soil. It also allows us, because of the rates of material that we're using to trace that for a number of years. And I think it's going to integrate really well with broader research themes that are going on. Each of those things together just adds a little bit more data together and lets us knit together a much more cohesive nitrogen management framework for the northern region, as well as Australia.

[00:13:31] **Professor Mike Bell, UQ** What we're wanting to do here is progressively sample a meter of plot, probably tomorrow actually, in another month or so we'll take another meter of plot. At maturity will take another meter of plot and each time we're looking at how much fertiliser nitrogen has got into the crop and at the end of the season we'll say okay, we can account for that nitrogen that's got into the crop, we can account for the nitrogen that's removed in grain, we can take soil samples and will account for how much fertiliser nitrogen is still in the soil and by difference we can get an estimate of how much nitrogen has been lost to the environment.

[00:14:13] **Darryl Anderson** The makeup of the research consortium reflects the national scope of the project and its potential value, with resources and people from each of Queensland University of Technology, University of Western Australia, Murdoch University and University of Queensland, CSIRO and the State Department of AG or Primary Industries in WA, South Australia, Victoria, New South Wales and Queensland.

[00:14:39] **Professor Mike Bell, UQ** The result of that will be, I think, one of the most comprehensive datasets anywhere in the world looking at the fate of fertiliser in cropping systems. And so in terms of processes, we'll understand the processes that drive nitrogen cycling into and out of organic matter or into those loss pathways, we'll be able to predict them better. We'll be able to use that data to help develop or get more confidence in the predictive tools like the computer models and stuff, which will tell us, given this sort of seasonal condition, you will have had a large loss event or not, or you should adjust your fertiliser rates accordingly. It's that broad swath of data and then being integrated into the predictive tools that the industry is using to make fertiliser recommendations that the real strengths will come out of this. The other thing that it will allow us to do, we're having more confidence in those sorts of tools, is to be able to do things like identify emission factors for greenhouse gas signatures for the grains industry, and that's going to become increasingly important in marketing our produce to the world because we need to be able to demonstrate minimal emissions per tonne of grain produced and that in some cases will be the entry requirement to particular markets. So by the end of this project, we'll have the data to be able to more confidently do an analysis across the grains industry and use that evidence based approach to emission signatures to credential our produce.

[00:16:16] **Darryl Anderson** How big do you think the payoff potentially is for being more efficient with our nitrogen use and turning more of it into grain?

[00:16:26] **Professor Mike Bell, UQ** The way I look at it is that the Australian grains industry spends between one and $2 billion a year on fertiliser nitrogen. So if we can improve the efficiency of that by 10%, that's some significant dollars that we'd be saving right from the get go. If we can improve our environmental credentials to gain access to markets that we couldn't otherwise access. I'm not going to try and predict what the value of that is, but to me that could be enormously important. And I think that sort of change in marketing and crop valuation is going to only become more significant as time goes on. So there's a whole lot of threads here that this work will underpin or contribute towards making better value for growers from this fundamental investment.

[00:17:11] **Darryl Anderson** Mike Bell, it's been really great to speak to you about this today and David Lester from Department of Agriculture and Fisheries in Queensland. Thank you so much for joining us on this GRDC podcast.

[00:17:20] **Professor Mike Bell, UQ** No worries. Pleasure to be here.

[00:17:29] **Darryl Anderson** In this podcast, we heard from Professor Mike Bell from the University of Queensland and Dr David Lester from Queensland's Department of Agriculture and Fisheries to hear more about how nitrogen loss occurs, there's a comprehensive GRDC podcast featuring Dr Graeme Schwenke from New South Wales DPI. Check it out via the link in the description wherever you access this one. This has been a GRDC podcast. I'm Darryl Anderson. Thanks for listening.x