# GRDC VIDEO TRANSCRIPT

**Boosting soil productivity using the Australian Synchrotron**

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

[00:00:12] **Fiona Fagan** Hello, I'm Fiona Fagan. The Australian Synchrotron in Melbourne is one of Australia's most significant pieces of scientific infrastructure. From outside, it looks like a large, circular-roofed football stadium. But on the inside, it's a super high-tech operation that produces powerful beams of light a million times brighter than the sun. In a partnership between GRDC, the University of South Australia and the University of Queensland, researchers have been given access to the Australian Synchrotron and it's giving them a perspective on soil they've never had before. They're using the Synchrotron's imaging and medical beamline to produce high-quality 3D imagery of roots growing directly into large, undisturbed soil cores. To find out more, I went to the Australian Synchrotron and caught up with the University of South Australia's Dr Casey Doolette and Dr Peter Kopittke from the University of Queensland, who took me on a guided tour.

[00:01:19] **Dr Peter Kopittke** So we're standing in the Australian Synchrotron in Melbourne, in Victoria, and we're standing at the IMBL beamline, the imaging and medical beamline. And so this is actually a really exciting facility to be in where we can actually collect X-ray images of roots growing within soil without even destructively harvesting the roots. So we're actually able to image the roots in the soil just like when we go to the doctor and get an X-ray image of our own bodies.

[00:01:43] **Fiona Fagan** And this room, is it called the hutch?

[00:01:45] **Dr Peter Kopittke** Yeah, we're standing in the experimental hutch, which has walls about one metre thick of concrete and heavy, lead doors, and that's, of course, to provide protection for us when we're outside and when the experiment's underway because there's a lot of X-rays, a lot of radiation in here and so this hutch is specifically designed to keep us as people safe while we're undertaking the experiment.

[00:02:06] **Fiona Fagan** What's that machine down there, right on the wall there?

[00:02:09] **Dr Peter Kopittke** Yeah, so we're actually standing quite a distance outside the main building of the Australian Synchrotron, and we can't see it from where we're standing but there's a long metal tube here which goes from here, underneath the road and back into the main building. And so, the X-rays are actually generated over in the main building and they come down this long tube and then they come out through that tube and then, standing right next to us here, we have our soil core. And so, we have some soil, this particular soil is from Queensland, and we have the soil core with some wheat growing in it. And the X-rays actually pass through this long tunnel, under the road and then through the soil core and the X-rays, we use them to image the roots within the soil. And then from that the X-rays continue down and into the detector where we can actually collect an image of what those X-rays look like.

[00:02:56] **Fiona Fagan** So Peter, we're now in the main Synchrotron building. It's really impressive. Just look out and tell me what we're seeing.

[00:03:02] **Dr Peter Kopittke** Yeah, we're standing on the mezzanine level at the moment in the main synchrotron building and we can look out over the Synchrotron facility itself. And quite privileged to be here, actually, when you look at this facility and the investment from the Australian government. As we look out, we can see the linear accelerator, which is where the electrons are generated and accelerated. They then go into the booster ring where they continue to be accelerated very close to the speed of light. And then from there they move into the storage ring, and the aim of the storage ring is to keep the electrons circulating until we use those electrons to generate X-rays, which we then use in the experimental hutch.

[00:03:39] **Fiona Fagan** Now this is only one of 50 Synchrotrons in the world. Is there anything unique about this particular facility?

[00:03:46] **Dr Peter Kopittke** The Australian Synchrotron is a really important facility. We have a range of beamlines here which can do experimental techniques. We've been using them to look at roots in soil. We can use it to look at Aboriginal artefacts, cultural heritage. We can use it to look at protein crystallography for drug development, a whole range of things and the Australian Synchrotron is really versatile in the range of techniques that we can do here.

[00:04:08] **Fiona Fagan** So how do the beams from the Synchrotron actually help with your research? What can you see that you couldn't see previously?

[00:04:16] **Dr Peter Kopittke** So the Australian Synchrotron produces light approximately one million times brighter than the sun. And this is a facility which we can do analysis which we just can't do anywhere else. And so here at the IMBL beamline, we're doing X-ray tomography just like you do at a hospital or a doctor, but we can do it so much better, so much brighter than what we can do in the hospital or at the doctor. And so, this is providing opportunities to examine things in much more detail, at a better resolution than what we can do anywhere else in Australia. And so this is a really exciting opportunity to use the capabilities that we have here to work with a whole range of researchers from GRDC and their field trials and to value add to the work which GRDC is doing in these various areas.

[00:05:01] **Fiona Fagan** So when it comes to soil and this GRDC investment, you've got three trials going on here at the moment. Tell me about them.

[00:05:09] **Dr Peter Kopittke** So this investment we have three projects. The first is to look at how can we visualise roots within soil, the hidden half. And so, this is trying to understand how roots respond to different fertilisers, how they respond to subsoil constraints, what can we do to manage these soils better and improve plant productivity. The second project we have with GRDC is about trying to understand soil carbon, soil organic matter. How can we build carbon within the soil? How can we build that organic matter to improve plant growth, but also to mitigate climate change? And we know that soil carbon is one of six priority, low-emission technologies from the Australian government. And so, it's about trying to understand how can we do this in a better way. How can we improve on what we're doing already? And then the third project is about trying to understand phosphorus fertilisers in soils, trying to understand how those fertilisers respond, how they behave differently in different soils, and how that is linked to plant growth, and trying to link all of that together so we can improve a plant response to those phosphorus fertilisers. So, these projects are approximately three years old now since we started and we're nearing completion now. And so, we're really at the exciting point of getting all of that data and really understanding what can we do better, what can we do differently to improve our farming systems and improve that profitability.

[00:06:25] **Fiona Fagan** And what results have you had so far?

[00:06:27] **Dr Peter Kopittke** We've had some really exciting and somewhat unexpected results as well. We found that the soils that we're using, the carbon within those soils, is not behaving as we would have traditionally thought. And for decades we've assumed that carbon in soils becomes persistent, it stays in soil because it becomes really complex. But actually, we haven't found that at all in this study. What we've found is that the carbon in soils doesn't really change. It doesn't matter how we manage our soil, that carbon stays the same. And so, this is telling us that the way in which we manage our soil to build carbon is not about increasing complexity, it's about managing that soil in a way that we're not disturbing the soil. It's about managing the soil in a way that we can actually increase carbon input to that soil and start to build that carbon back up. We need to try and minimise our disturbance of that carbon and we need to identify new and improved ways of building that carbon back up.

[00:07:20] **Fiona Fagan** So what impact will this have on growers and how can growers protect the carbon within the soils and harvest at the same time?

[00:07:27] **Dr Peter Kopittke** So we've been working with GRDC researchers in Queensland on a farming system trial where, for a number of years now, we've had a look at how different farming systems alter plant productivity. And we found from this there are different management practices we can put in place to actually build soil organic carbon back up. That includes using cover crops, it includes reducing disturbance to the soil so we're not losing that carbon by disturbing it. So, there's all sorts of different practices that we're identifying through this project, which can actually be used to help improve soil fertility and build soil carbon.

[00:07:58] **Fiona Fagan** So how does the research that you're doing here help farmers and help with their productivity?

[00:08:03] **Dr Peter Kopittke** So we've been linking with different researchers from across Australia, from Queensland, New South Wales, Victoria, South Australia over into Western Australia. And so, we've been working with them, value adding to the existing GRDC research, the existing GRDC investments, by providing additional information, additional insights, to help these researchers from across Australia better understand land management practices and how that influences soil and how that influences, ah, plant growth in these soils. And so, we've really been working with these researchers to improve their understanding and improve the outcomes from their research.

[00:08:39] **Fiona Fagan** And how are these trials taking your research to the next level?

[00:08:43] **Dr Peter Kopittke** A really exciting opportunity has been utilising the Synchrotron and the work we've been doing here in Melbourne has really been quite different to the sort of work which has been done before. Previously, the Synchrotron has really been focussed on the more microscopic scale, but this has been about translating that into a larger field scale and this has really been the exciting opportunity with GRDC. It's utilising these techniques, which we haven't done before, and utilising that to improve profitability for Australian farmers.

[00:09:13] **Fiona Fagan** And how has GRDC investment helped with what you're doing here?

[00:09:19] **Dr Peter Kopittke** Yeah, GRDC investment has been really critical, and this has been an exciting opportunity to take a facility which is traditionally used for examining fairly small, microscopic samples and use this to really extend into the field scale, working with farmers, working with other GRDC researchers. And so, this is really a whole new dimension to the work that we've been doing and it's a really exciting opportunity and we're thankful for GRDC for all of their support that they've made this possible.

[00:09:47] **Fiona Fagan** Dr Casey Doolette from the University of South Australia has been working in collaboration with Dr Peter Kopittke at the Australian Synchrotron.

[00:09:56] **Fiona Fagan** So what brings you from South Australia here to Melbourne, to this Synchrotron?

[00:10:01] **Dr Casey Doolette** So we're here to carry out experiments at the Synchrotron, which we can't do anywhere else in Australia. So, using lab instruments isn't really sufficient for our research. So, we come here to use Synchrotron, because the research we do here using the Synchrotron, we're able to analyse our samples with a much higher resolution and also much faster as well.

[00:10:23] **Fiona Fagan** How long have you been coming here to the Synchrotron, and what sort of work do you do when you come here?

[00:10:27] **Dr Casey Doolette** So I've been coming to the Synchrotron for this project since it began about three years ago. The research that we do here is on what's called the XFM beamline, the X-ray fluorescence microscopy beamline, and at that beamline, we're able to produce an image that shows the distribution of elements which are nutrients in DGT devices.

[00:10:46] **Fiona Fagan** So you're from the University of South Australia, there's also a GRDC trial happening here by the University of Queensland. How did the two universities work together? Do you work closely together?

[00:10:56] **Dr Casey Doolette** We do work really closely together. So, the GRDC has funded several projects that use the Synchrotron. So, over the last three years, we've worked quite closely together with researchers from the University of Queensland. Typically, what happens is research from the University of Queensland align with GRDC field trials, and they'll collect field cores, so cores of wheat or barley grown in the field, and then analyse them at a beamline here to look at the structure of the roots in that core. And then typically what happens is that core is then posted on the back of a truck to us in South Australia and we then cut that soil core in half, cut it vertically in half, and then, to look at the nutrients, we then deploy what's called a DGT device on the surface of the soil to look at where those nutrients are in relation to the roots. The ultimate goal is to look at the root architecture and how that relates to the distribution of available nutrients in that same soil core.

[00:11:51] **Fiona Fagan** So why is this research important?

[00:11:54] **Dr Casey Doolette** So this research is important because by better understanding how nutrients move in soil and in different soil types, we can then provide information to growers that will give them the information to be more efficient with their fertiliser use in terms of sort of depth of fertiliser application and what particular fertilisers are best in which particular soil type.

[00:12:15] **Fiona Fagan** Now you're based in South Australia, what are the challenges there with nutrients in the soil?

[00:12:20] **Dr Casey Doolette** Phosphorus is probably the big problem for South Australian soils because our soils are so alkaline, so they have quite a high pH and, obviously, therefore a high concentration of calcium carbonate. A lot of the phosphorus that we applied becomes locked up in the soil and not available for plant use. So that's probably our main limiting factor for most of our soils is phosphorus.

[00:12:40] **Fiona Fagan** Now let's talk about the DGT machine. What is it and how is it key to what you're doing?

[00:12:46] **Dr Casey Doolette** So the project we're working on is looking at the distribution of nutrients in soil and developing a method called DGT to map the available nutrients in soil. So, it's a passive sampling technique. It was first developed for use in aquatic systems but it's since been developed to be able to be deployed onto soil. And it's made up of three layers. So it has a protective layer, which is a very thin sheet of kind of paper, more or less, and then two really thin layers of gels. The middle layer is called a diffusive gel, and then the top layer is called a binding gel. So, nutrients diffuse through the diffusive gel and then they're attached permanently to the binding gel. And it's really a measure of the bioavailable nutrients in soil. Rather than investigating the total concentration of a nutrient in soil, it's only the bioavailable nutrients and the nutrient that can be taken up by the plant that actually gets absorbed by that binding layer. So that's really the advantage of the DGT, that rather than getting a total concentration, instead we're just looking at the nutrient that can be taken up by the plant. So that DGT device we deploy on soil, those very thin layers of gels. And then we take those three layers apart, and then we analyse that binding gel here at the Synchrotron to see where the nutrients are located in the soil.

[00:14:01] **Fiona Fagan** And what results have you had so far?

[00:14:04] **Dr Casey Doolette** Most of the project has actually been about the development of this DGT device. So commercial DGTs are quite small, about two centimetres in circumference. So, we've actually developed a much larger DGT, about fifteen centimetres by about ten centimetres, and so we've been able to successfully deploy that on field-collected soil cores. That's the data that we're analysing at the moment.

[00:14:26] **Fiona Fagan** And how is this research helping growers?

[00:14:28] **Dr Casey Doolette** So, ultimately, it will benefit growers by giving a better understanding of the fate of fertilisers in soil and making fertiliser use more efficient and also therefore a benefit in terms of cost as well.

[00:14:40] **Fiona Fagan** So how will it make fertiliser use more efficient?

[00:14:43] **Dr Casey Doolette** So if we can better understand the fate of the fertiliser, so when we put fertiliser in soil, how do those nutrients dissolve and what's the distance that the nutrients diffuse away from the fertilising granule and how that differs in different soils, how that's affected by pH or the different texture of the soil. We can then make recommendation about best fertiliser practice and therefore making fertiliser use more efficient.

[00:15:06] **Fiona Fagan** Casey Doolette, thank you for joining me today.

[00:15:09] **Dr Casey Doolette** Great, thank you for having me.

[00:15:17] **Fiona Fagan** Some fascinating research being done there at the Australian Synchrotron. That was Dr Casey Doolette from the University of South Australia and earlier I spoke to Dr Peter Kopittke from the University of Queensland. I'm Fiona Fagan. This has been a GRDC podcast. Thanks for joining me.