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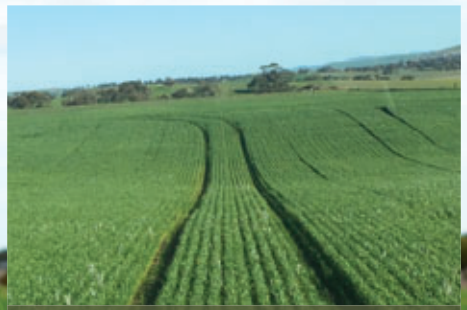

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President's Report

"The light bulb was not invented by trying to improve the candle. Real progress involves re-thinking how business is done rather than simply using new technology to replicate old processes". *– Digital transformation specialist Kevin Boyle*

Innovation is the cornerstone of best farming practise. However, achieving best practice doesn't always come easily and can take considerable time. When no-till was in its infancy, sceptics were quick to knock it. Some 20 years later, the benefits of minimal soil disturbance are well documented.

If we are to remain at the cutting edge we cannot rest on our laurels. Nor can we be confined to mainstream thinking.

Soils scientist Dr Albert Rovira once said his research aimed to be decades ahead of the farmer – that is, he wanted to have time to do his work and to prove the long-term viability of his findings before they were adopted by the masses.

West Australian inventor (and WANTFA founding member) Ray Harrington was propelled onto farming's world stage with the Harrington Seed Destructor; his brilliant weed control system adapting technology that was previously the domain of the mining industry.

SANTFA is proud of its role in moving farming towards a more efficient and sustainable model and, like Rovira and Harrington, the board is looking long-term and is open to adopting advances made in other industries to further its aims.

An example of this approach is SANTFA's development of AquaTill, which uses high-pressure water jet technology more typically associated with cutting through steel, to cut through heavy surface residue loads to enable efficient, accurate seeding of crops. We believe this research, which represents out-of-the-box thinking, has the potential to dramatically improve seeding practises.

SANTFA has recently been awarded $698,000 from the Smart Farms component of the National Landcare Program to conduct national trials of the AquaTill technology, which has attracted commercial interest from as far afield as Canada.

We will not to be confined to traditional methods in our quest to improve agriculture for the future. Neither should you. Be prepared to push the boundaries, think creatively and challenge convention. The light bulb wasn't simply an improved version of the candle; it was an innovation that has been credited with changing the world.

Let's all strive for real progress in agriculture and reimagine, rather than settle for reinventing, the wheel.

Callum March

Exploring the potential of liquid nutrients at depth

SARAH JOHNSON

A grower syndicate on Eyre Peninsula is testing the theory that applying liquid nutrients at depth will prolong crop responses to deep ripping.

Four farming families from Buckleboo on SA's Eyre Peninsula have joined forces to trial the effects of injecting liquid nutrients at depth during deep ripping.

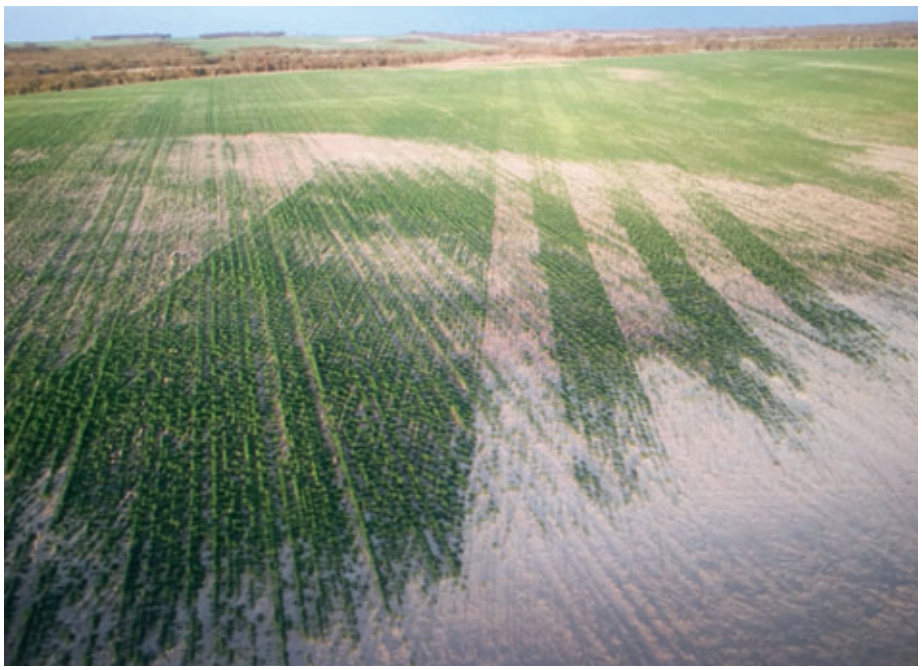
The syndicate hopes to build on deep ripping benefits by boosting crop root growth in the subsoil. Crop responses to deep ripping identified in initial trials include better germination, greater biomass and improved frost tolerance.

Group spokesperson Tristan Baldock, a former agronomist, said the trials are designed to test the theory that providing additional nutrition at depth will help delay resettling of the soil by encouraging sub-soil root development to increase root mass and create root channels.

"If we're going to make the most of the ripping process we need to create an environment that facilitates rapid root development at depth," he said. "We need to establish rooting channels in the first two years before the soil reconsolidates.

"With deep ripping we create a bigger bucket of water for the plants to access and we want to make sure there is also nutrition lower in the profile.

SEEING IS BELIEVING. THIS SOIL PIT GAVE GROWERS A CLEAR INSIGHT TO SOIL STRUCTURE AND ROOT DEVELOPMENT AFTER DEEP RIPPING ON THE BALDOCK PROPERTY.



AGRONOMIC TREATMENTS WERE OVERLAID ON RIPPING TREATMENTS IN THE FARM-SCALE TRIAL TO ASSESS THE IMPACT OF DEEP RIPPING AND OTHER SOIL AMELIORATION OPTIONS.

"We're trying to work out how we can take ripping further and get even more value out of it, and we're not going to know unless we have a go."

Trial extension

The latest trial is an extension of research conducted by the farmer-led Buckleboo Farming Improvement Group (BFIG) during the past four years to find the best way to improve the volume of soil accessed by crops in the region's orange-red sand.

Soil types at Buckleboo range from grey calcareous over limestone through red chromosols over clay or limestone to deep orange-red sands and white sands over clay. The orange-red sand soils typically have a 100mm layer of topsoil that is greyer in colour due to higher organic matter content over deep orange subsoil with no organic matter and consolidated

layers at 150-200mm and 450-500mm below the surface.

The initial BFIG research was a fully replicated trial exploring the impacts of 15 different subsoil and soil amelioration treatments including deep ripping, delving and spading in conjunction with the addition of several different sources of organic matter on these high soil strength soil layers.

The results showed that deep ripping with a Paxton Plow soil renovator produced the best results because it fractured the subsoil without lifting it to the surface, an important factor in soils that are typically high in boron and carbonate. "The idea behind the Paxton Plow and its shank design is not to lift the soil like a delver or some other rippers do," said Tristan. "It's about fracturing without lift.

"Carbonate is more of an issue than boron levels in sands with consolidated layers because it forms a barrier that inhibits root growth physically and chemically, so if you bring carbonate up to the surface you're going to have issues with nutrient availability.

"In these orange-red sands there's a high-carbonate hard layer at 450-500mm depth and we want to make sure we don't bring that up to the surface."

Given the levels of carbonate in the deeper hard layer the syndicate is focusing on the shallower hard layer at 150mm, which Tristan is quick to point out is a natural consolidated layer and not the result of compaction from farming.

"We tend to refer to what we're dealing with in our soils as compaction but often it's not. If you take a shovel and walk out into Mallee scrub that's never been touched the same layers are there. It's not compaction that's created them, it's the natural consolidation of that soil type.

"If we do nothing else to the soil after it's ripped, natural weathering will reconsolidate it back to the same condition over time. What we're hoping is that by using liquid nutrients to encourage good deep-soil root development we can slow the reconsolidation process."

Deep liquid

The syndicate has settled on liquid fertilisers as the most cost-effective way of getting nutrients deep into the soil profile. The BFIG trials showed benefits from applying organic matter but the cost of that approach is prohibitive for a large-scale commercial application.

"The BFIG trial showed there is benefit from applying organic matter at depth but that's expensive," said Tristan. "Liquids weren't part of that trial and from what we can understand ours is probably the first commercial application or larger-scale analysis of using liquid fertilisers in this way. That means there's not really any reference we can go by but we think the theory is sound. We've opened up the soil bucket for the plants to access; now we need to feed them so they can access the extra water in the bucket."

The farmers taking on the research are Brett and Mark Zibell, Paul and John Schaefer, Dion and Bert Woolford and Tristan and Graeme Baldock, all members of BFIG with land in the Buckleboo area. The Woolfords also have land south of Kimba that includes areas of non-wetting white salacious sand.

The syndicate bought a Paxton soil renovator for approximately $100,000 and have fitted it with liquid application equipment from Adelaide-based Liquid Systems (SA). It has also been fitted with inclusion plates that direct soil into the furrows behind the tines.

They explored three options before deciding on Liquid Systems equipment, which two members of the group use to apply nutrients at seeding.

"We looked at Peter Burgess' Liquid Systems set-up plus another company's equipment and considered building something ourselves," said Tristan. "We decided to go with a system like Peter's because we know it works and it's going to be a saleable item if we find this whole theory doesn't work. It's still a sound unit that someone can put on their seeder."

The ripper was fitted with the liquid application equipment and was ready for use by earlier this year but the process took a month longer than anticipated due to setbacks including equipment delivery delays and a series of 'engineering challenges'.

"However, I guess they were the sorts of things you should expect when you're setting up something new and the plan is not much more than a sketch on the back of an envelope," Tristan said.

This year's trials began on April 1, with each of the growers ripping approximately 50ha; considerably less than the total 800ha planned.

"The area was nothing like we'd intended because the soil was dry, which made the ripper hard to pull, plus the soil was coming up blocky, which isn't ideal. We'd planned to do closer to 200ha each. Horse power wasn't a problem; we've each got a tractor with about 450 to 550 horsepower. The trouble was getting enough traction. There was a lot of wheel slip."

SOILS IN PADDOCKS USED FOR THE RIPPING AND SOIL AMELIORATION TRIAL WERE SAMPLED IN DETAIL AHEAD OF THE TRIAL TREATMENTS.

They achieved an average working speed of 2.5km/hr over the area they did manage to treat in the dry conditions, about half their target rate of 5km/hr.

In consultation with Adelaide-based fluid fertiliser company SprayGro the syndicate decided to use chelated trace elements in the nutrient mix rather than the sulphate forms commonly applied in-furrow during seeding by growers using liquid fertilisers.

"Sulphates would have tied up very quickly in our highly alkaline subsoils, whereas the chelates have protection around the nutrients to stop the high alkalinity attacking them," said Tristan.

"We had to spend more money on chelated nutrients to make sure they will be there for the plant when its roots get down there.

"Most growers applying fluid nutrients at seeding time put them down as sulphates because in that situation they are right there with the seed in the topsoil and we want them available within the first 10 weeks. When we're putting liquids down in the subsoil we're looking for nutrient to be available for a longer period."

The trial areas have been treated with 200L/ha of a mixture of copper and zinc plus phosphorous (P) in the form of

ammonium polyphosphate (APP), rather than the phosphoric acid often used as a phosphorous fertiliser for topsoil applications. "Rather than phosphoric acid, which a lot of growers use down the seeding tube, we applied our deep-soil P in the form of APP to give it some protection," said Tristan. "If we'd put a really low pH phosphoric acid, which is cheap, down into our high pH sub-soil there would have been a big chemical reaction. If you can imagine something that's pH1 and something that's pH9; they're going to react very violently and essentially tie up that P. The APP is slower release and will be there for longer."

On the Woolfords' Kimba property, where they treated non-wetting white sand country with a neutral to slightly acidic subsoil, the syndicate used the sulphate form of the trace elements plus phosphoric acid on some of the area and the more expensive chelate and APP on the balance with the aim of comparing the two treatments in that soil environment.

"Dion used some of our brew to see what difference it will make because the chelate and APP combination costs about $80/ha, whereas using the sulphates plus phosphoric acid costs around $50/ha. That's an extra $30/ha to put a safety net around the nutrients, but we're hoping it's worth it. It's a bit of trial and error."

Tristan is hoping GRDC and BFIG trials also underway in the Kimba district, including on his family's property will clarify the types and rates of liquid nutrient inputs needed to achieve a beneficial outcome in EP soil types. Treatments in these trials, which are part of the GRDC's national Sandy Soils Project that also involves CSIRO and PIRSA, include ripping to 450mm and 300mm with and without inclusion plates, multiple rates of different nutrient mixtures and an application of APP with no trace elements.

In the BFIG trials on the Baldocks' orange-red sands and the Woolfords' white sands the focus is on the nutrient packages, with ripping to 450mm and use of inclusion plates standard across all treatments. The nutrient treatments in this replicated farm-scale trial, which is being funded by the Eyre Peninsula Natural Resources Management Board (EPNRM), are different rates of the syndicate's 'standard' mix of chelated zinc and copper plus APP and an APP only treatment.

THE TRIAL SYNDICATE'S PAXTON PLOW OPERATION [TOP] AND THE TINES AND SHANKS [BOTTOM] THAT SET IT APART FROM MANY OTHER DEEP RIPPERS. THE TUBE IMMEDIATELY BEHIND EACH TINE IS POSITIONED TO DELIVER NUTRIENT INTO THE RIP LINE TO ENCOURAGE DEEP ROOT DEVELOPMENT.

"It's about exploring the economics and testing whether there's a ceiling for this," Tristan said. "If we don't see any effect from applying $80/ha worth of liquid nutrients; is there an effect at $400/ha? If we discover there's no effect with either rate then it's lights out on this project.

"The GRDC trials are a great way to add that scientific and statistically-sound element to what we're doing, while the BFIG trial allows us to extrapolate it out to a broadacre demonstration, with replications on the red and white sand. The combination will hopefully give us some pretty good information come next year when we get organised to do it again."

Liquid technology

Choosing the best nozzle for application of liquid nutrient while deep ripping proved a challenge for the syndicate members and their consultants.

Peter Burgess, from Liquid Systems (SA) suggested two different options; a nozzle engineered for harsh conditions and typically used to fumigate potatoes or a cone-shaped nozzle used by a Liquid Systems' customer in SA's Mallee region. Given the cost of the first option, they decided to go with the second.

"The plan was to have a nozzle sitting just above the inclusion plate so the cone-shaped

BIG FIG DRIVING RESEARCH, BUILDING COMMUNITY

A 100% volunteer-run, farmer-driven group is driving agronomic research and building community on upper Eyre Peninsula.

The Buckleboo Farm Improvement Group (BFIG), known by its members as Big FIG, is committed to collaborative research work, pursuing the latest technology solutions and building a cohesive social network for its members.

The group, recognised as one of the most active grower groups on EP, was established in 1997 when two local growers set out to reinvigorate the local Agricultural Bureau.

"They immediately formed a close relationship with the research community, particularly the Minnipa Agricultural Centre and the University of Adelaide," said Buckleboo grower Tristan Baldock, a current BFIG committee member.

"The group has always been fairly progressive. In the early days they built a trial seeder that was capable of deep ripping to 400mm and injecting liquid gypsum at depth. That was in the late 1990s."

Twenty years on and BFIG has come full circle, establishing trial sites to test the impact of applying liquid trace elements and phosphorous during deep ripping.

It contracts some of its research work to Minnipa Agricultural Centre (MAC) to reduce the workload on its members and to support the research centre.

Agronomic research is a key focus for BFIG but isn't the only item on the group's agenda. Last year it established a network of weather stations and moisture probes, providing its 50 members with access to real-time local weather and soil moisture data. It currently has 10 weather stations with plans for more.

The weather station project was financed partly by grant funding and partly by growers participating in the scheme. Farmers like the Baldocks, who host a weather station on their property, contributed about $3,800 of the total $7,500 cost of the station. Much of the grant funding came from the Federal Government's $2 million Radioactive Waste Facility Community Benefit Fund (RWFCBF), a resource BFIG has been able to access because of Kimba's bid to host the national radioactive waste facility.

It has successfully applied for more than $100,000 from RWFCBF; funds that have been used for the weather station project, an oats variety study and a feasibility study for a multi-user grain storage facility in Kimba.

"Export hay has grown dramatically in the district in the past three years so we've subcontracted Minnipa to look at oat variety selection and conduct a study into where hay fits best in the rotation in our district," said Tristan.

BFIG also runs a series of regular activities including an annual farming system update in March and in most years organises a bus trip to another SA farming district. It also usually hosts an annual local crop walk but two years ago organised a strategic tillage field day instead of the 'walk' – usually a procession of utes. The field day attracted 140 people – farmers, researchers and advisors – from across SA, who descended on Buckleboo to spend a day in soil pits looking at the impacts of strategic tillage, Tristan said.

BFIG's latest venture is a Women in Ag program aimed at helping women become more involved in the industry. 15 participants have signed up for this year's program, which is supported by Grain Growers Limited, AWB and EP NRM.

"We've wanted to introduce a program that gives women a better understanding of the whole industry, particularly what happens in the paddock," said Tristan, who is driving the initiative. "It kicked off this year and the feedback has been overwhelmingly positive. The first session was about getting the crop in and understanding rotations and crop types and the participants visited a farm using two different seeding systems. They also have homework to do; germination tests and things like that.

"I suppose it's something else going on that helps keep the group relevant to the area."

BFIG is also working to widen its member base but is not getting as much 'traction' as it would like. While its name suggests a Buckleboo focus it is the only grower group in the broader Kimba district so the committee is keen to expand its membership reach to Kimba and beyond.

"We've worked pretty hard over the past few years to increase our footprint and have done a lot of things to encourage farmers from outside our original area including shifting our regular meetings into Kimba. We have also located two of our weather stations to the south, outside our normal catchment zone, so members in that area can access live local weather and soil moisture data. Part of the decision to put stations into that area was about putting a value proposition to potential members down south.

"For $80 a year BFIG membership you can have live weather data. How cheap is that?"

spray provided maximum coverage on the topsoil as it folded into the trench," said Tristan.

"However, we found the cone nozzles didn't have the output capacity we needed and in trying to achieve that we ended up with very fine droplets we decided were no good. We need a nozzle that can produce a coarse droplet at high water rates.

"The next idea was splitting the delivery lines at the terminal and fitting two nozzles at each tine instead of one. We also considered delivering the nutrient in a solid stream, and after talking to many different people decided that was the way to go, because while the spread would be less, there would be bigger pockets of nutrients distributed in the profile.

"We planned to compare double cone nozzles and solid stream but it didn't happen, so that's there for next year."

The syndicate plans to continue its trial work over the next five years. The members hope to see results from deep ripping this year but don't expect to see any impact from the liquid nutrient applications for another three or four years.

"We'll know the results from the nutrient applications when we dig up those rip zones and see if there is any physical difference in the root architecture in the subsoil," said Tristan.

He sees the current BFIG trials and kindred research as building on the benefits achieved through no-till farming over the past 20 to 30 years and believes insights from the current research have the potential to ensure a future in agriculture on EP despite climate challenges.

"This is about making sure we're here in 20 years' time," he said. "It's about getting the most out of land that is becoming increasingly tightly held and commanding higher prices than can be justified by its production capacity.

"If we have to pay $1,000/ha for land that productively is worth $250 if we want to expand, maybe it would be better to spend an extra $250/ha on the land we've already got and lift its production by 30 or 40.

"The current environment is another factor. It was noticeable that ripped areas handled last year's frosts a lot better than un-ripped areas.

THE ROOT DEVELOPMENT OF THESE LENTILS IS EVIDENCE OF RESPONSES BEING ACHIEVED FROM THE USE OF DEEP RIPPING AND ASSOCIATED NUTRIENT AND AMELIORANT TREATMENTS.

"From here it's about working out how we can fine-tune the process to make sure we're investing our money in the right places.

"If we get to the end of three or four years with no obvious benefit from injecting the nutrition, then we move on. It's a collaborative process. We're all going to win or we're all going to lose a little, as opposed to going it alone and losing a lot."

Mallee growers building confidence and the production base

SARAH JOHNSON

Livestock are increasingly taking centre stage for the Pocock family, but no-till practices and higher-input farming are also generating benefits for the Mallee-based mixed-enterprise farmers.

Mallee farmers are shedding their reputation as the 'poor cousins' of SA agriculture, according to Lameroo farmer Robert Pocock, with a combination of higher-input farming, no-till and other system advances leading to improved crop performance in the Mallee region.

Robert sees robust results achieved last season despite low growing season rainfall as testament to the progress Mallee farmers are making.

"Last year, one of the directors of Mallee Sustainable Farming received far less than 100mm of growing season rainfall and grew a two-tonne barley crop. That's a farm average, not just a paddock," he said. "And this year they've had only 26mm for the season and still put in a full program. I can't believe their confidence, but it's sensational to see that happen.

"Last year we had 135mm of growing season rainfall and some of our crops were 3t/ha. I think it's about nitrogen management, summer weed control and rotation. We're getting crops up and going and getting the root systems healthy early. In my opinion it is opening up the Mallee.

"It's not just nitrogen, it's the whole system. No-till is starting to work really well in some country. It's still hard work in sandy soil but on good loamy dirt it doesn't fail.

"We still have to work within our limits but I think we can extract more out of our land than we ever knew."

He believes the key is Mallee farmers harnessing a new sense of confidence and being prepared to take more risks with inputs than they have in the past.

"The conservative Mallee view had been holding us back. We had a few really good seasons where we didn't capitalise as much as we could have. For example, in 2010 we had 500mm of rain and none of us would have fertilised to that potential. We probably should have achieved 6t/ha averages, but in our environment none of us were game enough to do that, to continue feeding our crop to get to that point.

READY TO ROLL. THE POCOCKS' SEEDING RIG IN TRANSPORT MODE IN A PADDOCK THAT STILL HAS PLENTY OF SOIL COVER DESPITE RECENT TOUGH CONDITIONS.

"It's a higher input farming system. It's something my father and grandfather wouldn't have been comfortable with but they were farming with two years of pasture followed by wheat or barley: barley sown on the hills and wheat on the flats. Now we're trying to do more intensive and tighter rotations."

Establishment is the biggest issue with medics.

Robert runs the family farm, Lampata, near Lameroo with his wife Courtney and parents Bruce and Gaylia. The 3,000ha property carries a Poll Merino stud with 2,100 breeding ewes and a cropping enterprise growing barley, wheat, vetch, lupins, hay and perennial pastures. The family also runs a contract seeding and harvesting enterprise that sows up to 1,800ha annually.

Robert is vice chair of Mallee Sustainable Farming (MSF) and attributes the family's ability to keep abreast of the latest information and farming strategies to their involvement in research. They have hosted GRDC National Variety Trials for at least 50 years and more recently welcomed a CSIRO Agriculture & Food 'pastures in cropping systems' trial exploring the suitability and potential value of novel legume pastures for the Mallee environment.

"I really encourage other farmers to consider hosting trials," said Robert. "It's great to have them on your farm because you can go out there when there's a researcher around and sometimes get 15 minutes with them. It's pretty invaluable to talk to these people who are at the cutting edge of research."

MSF research into nutrition management of crops on sandy soils has had a major impact on Robert and his family's enterprise, giving them confidence to increase inputs.

Using a triple bin seeder they apply a minimum of 27 units of N/ha as urea at seeding and up to 40 units of N/ha as urea in-crop if the season looks promising. It works out to about 100kg of urea in a good season.

"We've followed this strategy more confidently in the past six or seven years," said Robert. "We picked up the idea pretty quickly after seeing the MSF trials at Karoonda. They were putting out high rates of nitrogen on Mallee sand and the payback benefit was quite good. I think it was a minimum of four to one on

average, year in, year out on mid slopes and sandy soils."

The Pococks have about 60% of their property, mostly sand hill zones, under permanent lucerne or veldt grass pasture and have recently increased the amount of nitrogen (N) being applied to their veldt grass, a South African perennial Robert describes as 'magic stuff'. Some of the family's veldt pastures were planted up to 50 years ago.

"We're starting to apply more urea in our grass-based pastures. They need N just like cereals, and if we don't grow the bulk we need in our pastures we can't feed our livestock to their potential."

The upturn in the livestock industry over the past 10 years has seen the family increase their grazing enterprise, with sheep now constituting almost 70% of their business. "We are putting our focus on the sheep. With the profit margins in livestock we just have to chase it. It's like the growers who went flat out growing lentils, chick peas and faba beans. Sheep our are lentils."

Putting greater emphasis and energy into livestock has seen the family make compromises in their grain enterprise. "It's our biggest challenge," Robert said. "There's always a compromise and at the moment, with the dollar value of sheep, we are compromising on grain management and we have to be aware of that. It's really affecting what we're making out of cropping."

The eight months leading up to this year's season break was the property's driest eight months in recent memory, Robert said and the consequent lack of feed put pressure on their cropping paddocks. This in turn led to overgrazing, and strong winds in early autumn led to soil erosion.

"It's very expensive to put all our stock in containment and feed them," he said. "We would have been up for 50 or 60 tonnes of fodder a week from December all the way through to the start of May and we don't have the resources to be able to do that.

I think it's about nitrogen management, summer weed control and rotation.

"We decided we had to make that compromise and put our pastures under pressure, which we recognise is not good environmentally and has set some of our paddocks back a good few years. This year we've sown a lot of them rough because they were a bit wind-blown so next year we're going to have to cultivate a few and level them up. Once we have plenty of residue on top we can start again."

To support their increasing livestock enterprise the Pococks have begun re-establishing medic-based pastures – to replace some of their legume break crops – they spray out in spring and cut for hay.

"It's not a new technique by any stretch," said Robert. "The old ley farming system from the '50s, '60s and '70s, which used to be two medic pastures then a cereal crop, was a self-regenerating medic system.

"It's really just a matter of establishing a large seed bank in the soil then managing the weeds. You have to be prepared to spray them out, but that's just par for the course.

"Once the seed bank is established the medic pasture will regenerate itself when the conditions are right. Then all it needs is a bit of fertiliser and herbicide to keep it clean. It's a low-risk system, the sheep get high-quality tucker and we avoid the cost of having to sow a legume each year.

"It might also mean less risk on the cropping side because I won't have to rely on getting so much of my N out of the bag, so I might be able to reallocate more of my urea budget to our sandier ground where I can't grow as many good N-fixing crops."

The Pococks have so far sown about 20% of their flats to current medic varieties, with this year's late season break providing a reminder that there can be a down side to the hardy legumes in late seasons.

"Establishment is the biggest issue with medics. If we get a late break they don't tend to perform very well and this year they were very, very ordinary, with

SHEEP CAN PUT CROPPING PADDOCKS UNDER STRESS UNLESS THEY ARE CAREFULLY MANAGED. ROBERT POCOCK IS HOPING A RETURN TO SELF-REGENERATING MEDIC PASTURES WILL IMPROVE THE SHEEP ENTERPRISE AND HIS CROPPING OUTCOMES.

individual plants the size of a 10 cent coin in mid-June. If it had rained in early April there would have been a carpet of medic 75mm deep across the paddock by then. They don't grow good biomass unless you get an early start, so in late seasons we're likely to need to go into medic paddocks and sow a cereal to provide bulk and cover."

Re-discovering medics is a case of 'everything old is new again' for the Pococks, who had medic-based pastures in their system up to 35 years ago, but there are some differences this time around. They are using modern cultivars that are tolerant to Group B herbicides and are hoping to draw on results in the CSIRO novel legume pastures trial on their property to identify varieties well suited to their sandy soils.

"You need varieties that will match the soil type because medic pastures can be fickle," said Robert. "We're very lucky to have that trial on our property. The work is being done on our sand hills and while the performance of most of the lines in the trial was pretty ordinary last year, this year a few of them are looking quite promising. They have all set seed and managed to regenerate but they haven't been grazed yet. Grazing persistence is the next step.

"I look forward to being able to grow a self-generating legume pasture on sand. It would be very exciting if we can get that to happen."

At the moment many of the Pococks' sand hills are planted with veldt grass.

Adding medic pastures to their cropping rotation is an example of the Pococks' 'multiple use' crop philosophy. Apart from lupins, all of their crops can be used in several ways – for grain, grazing or hay-cutting. For example, they don't grow what Robert describes as 'sexy legumes' such as beans, lentils or chickpeas because they are single-use crops. "You can't do anything else with them except reap them," he said. "If they get frosted you can't cut them for hay and you can't use them for something else.

"We really have to make sure all our grain crops have two or three potential end uses. Lupins are the only crop I grow that I can't do something else with other than feed them to stock or sell them."

Vetch, with a 'splash of canola' to provide 'trellising' and help keep it up off the ground, is the usual legume break crop in the Pococks' cropping rotation. The vetch, which can be fed to lambs or cut for hay, is followed by two cereal crops, either wheat and barley or two barley crops, with barley fitting well in the Pococks' 'multiple-use' strategy. "We can sell barley or value-adding it by using it to feed sheep in the feedlot when we need to hold them out of the paddocks; something we're looking at doing a bit more. Plus barley tends to grow better on some of our harder cropping country."

In addition to fine-tuning their crop rotations the Pococks have adopted several new strategies and technologies to improve their cropping enterprise. These include variable rate application of fertilisers and chemicals, controlled traffic farming and liquid application technology to apply nutrients and chemicals in-furrow at seeding. However, not all new ideas are immediately successful, with Robert currently working towards tackling variable rate (VR) application again after a break of almost 10 years.

We really have to make sure all our grain crops have two or three potential end uses.

Between 2006 and 2010 he 'went pretty hard' with VR, using it to manage application rates of herbicides, nitrogen, phosphorous and seed on the basis of EM38 mapping, NDVI imagery, 10 to 12 years of yield data and hand-drawn maps based on the family's knowledge of their paddocks, he said. However, despite the significant amount of time and effort spend coming to terms with the technology in that period, he decided he needed to get the basics such as weed management, establishment and rotations right before pursuing it further.

"I need to be confident in the country I'm doing it on; that the paddocks are up and running well, that it's a healthy system."

There were also management issues. "I was collecting so much data it was getting hard to manage and there was a lot of conflicting information. Getting our staff to understand it and use it effectively was a challenge too."

Staff understanding of controlled traffic farming (CTF) is also an issue, particularly with casual staff they employ during peak periods. Robert doesn't consider his system, which is based on a 12m working width, to be full controlled traffic because of the livestock and hay operations.

The Pococks, who have a 12m seeder and header and 36m sprayer, this year went 'back in time', replacing their seven-year-old John Deere seeder with an 18-year-old Primary Sales precision seeder Robert describes as a high trash flow version of a DBS seeder. "It's quite an impressive machine," he said. "We just refurbished it and it did a fantastic job this season. I'm very impressed. It has got really good digging depth and good trash flow."

The 'new' seeder is fitted with a self-built liquid delivery system used to apply a triple trace element mix in the furrow and a combination of soil wetter and insecticide at the surface behind the press wheels. The Pococks have used liquid fertilsers at seeding for the past four seasons and Robert believes they have provided financial benefits and improved system flexibility.

"I'm not sure if we're any better off agronomically using liquids instead of putting trace elements into fertiliser but economically I think we're in front. We can use different products down the tubes and our herbicides don't have to be compatible with the trace elements, so we're saving on those costs and are probably putting on more than we used to."

The family use RTK precision seeding technology to ensure they're able to make the most of moisture in the furrow. "RTK implement steering on the seeder enables us to sow on-row, off-row or near-row," said Robert. "When it's pretty marginal moisture, sowing on top of last year's row or as close as we can to it is pretty important. It's always wetter on the previous crop row than it is in the inter-row. On sand, sowing on the row or row edge is better than sowing in the inter-row for weed management and crop establishment."

They are now considering clay spreading or delving to address issues in some of their soil types. Robert has been hesitant to adopt these soil amelioration techniques due to mixed results in the Mallee, but is committed to improving soil health and believes there could be some benefit in the right circumstances.

"I just want to build a nice, sustainable, healthy system that's not super complex. I want to go out in the paddock and know that we've got a healthy farm."

Working together for a future in farming

SARAH JOHNSON

Science and a spirit of innovation are key elements of the farm business being developed by two WA growers to withstand and adapt to the realities of climate change.

Building a resilient farming business able to cope with climate variability is a key focus for WA mixed enterprise growers Simon Wallwork and Cindy Stevens.

The couple, who have farmed together at Corrigin in the central wheat belt since 2003, is employing strategies that spread the risks posed by drier winters and more severe frosts.

These include running livestock, growing crops with different-length growing seasons to counter frost risk, planting summer fodder crops and amending non-wetting soils with mould board ploughing.

Simon, a qualified agronomist, has tracked significant changes in rainfall in the Corrigin district since 2000, with winter rainfall decreasing by 15%. There is a trend to slightly more rain in the later part of the growing season and during summer but the season break is less predictable.

"The breaks have gone backwards a bit," he said. "There's less reliable rainfall in May, in terms of larger rainfall events, and I believe our springs are getting softer, so the whole season has shifted backwards a fraction."

SIMON WALLWORK IS WORKING HARD TO IMPROVE THE RESILIENCE OF HIS FARMING ENTERPRISE.

SIMON AND CINDY ARE HAVING CONSIDERABLE SUCCESS WITH PASTURES OF SUMMER-ACTIVE SPECIES LIKE THIS HEALTHY STAND OF MILLET IN A RECENTLY MOULD-BOARDED SOIL.

A higher incidence of frost and widening of the frost window are other concerns for growers at Corrigin. "We've had some severe frost events through this part of the wheat belt since I started farming. Speaking to older fellows around the place, they don't think they experienced the same severity of frosts in the past, and work by the CSIRO has shown that the frost window is opening up," Simon said. "We're getting frosts later and also more severe frosts. It's something we have to consider with our farming systems."

Simon and Cindy operate a 3,700ha property previously owned by Cindy's parents. They run cattle and sheep but cropping is their main enterprise. They use a no-till system, sowing their crops with a 12m DBS Auseeder with parallelogram-mounted knife-points and press wheels.

The couple's cropping rotation is weighted towards barley, which is more resistant to frost than wheat, with their usual program about 60% barley, 20% canola, 15% wheat and 5% lupins.

"Barley still gets damaged by frost but it doesn't tend to get wiped out like wheat has at times," said Simon. "I've had frost knock wheat yields down to 200 or 300kg/ha, whereas typically with barley you might bottom out at around 800kg to 1t/ha. It's a fair difference." They sow multiple barley varieties with different-length growing seasons to stagger the flowering and harvest windows to spread seasonal and frost risks.

Stubble burning has also become part of their frost risk reduction strategy since Simon became aware that residue can prevent the soil from absorbing heat from the sun during the day. "In the past I was fully against burning but I am finding it helps with weed seed management and there are some frost reduction benefits," said Simon. "There's some evidence that stubble can increase the risk of frost damage because it insulates the soil from the sun's heat. Burning won't prevent a severe frost but trial work done in our area shows it can make a difference."

Simon and Cindy have used a chaff cart

to capture and remove weed seeds at harvest but for the past four years have burnt windrows of header chaff on 40% of their property each year with the dual aims of destroying weed seeds and reducing residue cover to lower the risk of damaging frost. To form windrows the standard spreaders on their two headers are replaced with chutes that concentrate the residue from the machines into rows that are burnt after harvest. While the aim is to burn only the windrows, Simon is not too concerned if all the stubble in a paddock burns because of the reduction in frost risk.

The livestock are a relatively small part of the couple's overall enterprise but are integral to their evolving farming system, being used to strategically manage weeds and generating an income stream that provides a buffer against the risk of losses from the cropping program due to frost or other seasonal factors. They currently run 200 Murray Grey cows and 600 Merino ewes that are mated to White Suffolk rams to produce lambs for meat.

"The livestock have been profitable relative to cropping gross margins," said Simon. "Livestock markets are strong and there's more demand coming out of Asia I believe, so that helps."

He sows fodder barley early in the season to provide grazing for the stock over winter. These cereal pasture paddocks are then sprayed out in spring before any weeds set seed. "We sow the fodder crops early in April then knock them down with glyphosate in September – hay freeze – to ensure any weeds that are there don't set seed."

In the past few years Simon and Cindy have also sown summer fodder crops to take advantage of their summer rainfall.

"We've been slowly increasing the area sown to summer fodder. It's mainly millet, but I'm moving more towards a blend now," Simon said.

Last year they used a 7:1:2 blend of millet:sudan grass:sorghum.

"I don't want full forage sorghum because there is risk of prussic acid poisoning, which is an acid the plant produces that can be toxic to livestock. I think a mix is a way of managing that risk.

"Last summer, which was quite dry, the millet performed OK but the forage sorghum and sweet sudan grass, which tend to have a slightly different way of establishing their root systems, did really well. Millet needs wet topsoil to get going but you can sow the forage sorghum and sweet sudan grass deeper into moisture and the roots will keep chasing that moisture down. It means you're not as reliant on more rainfall, which is pretty unreliable at that time of year.

"The sorghum and sudan grass were quite productive in last year's dry conditions."

They sow their summer fodder mix at a rate of 10kg/ha in areas where Simon thinks the summer-growing species will do well.

"I choose areas where I think they'll perform; usually lower in the landscape where the soils can store moisture and where we've had a chemical fallow over winter. If we can establish and graze green feed over summer it's another way for us to control winter weeds and get weed seed numbers down."

Simon is also seeing a yield response in winter crops following stands of summer pasture.

"I've seen quite large yield responses in barley sown after summer forage, with yields from those crops considerably better than from barley sown on barley the year before. I did a couple of trial strips last year and there were quite large differences.

"Some people argue that you're using all your soil moisture with a summer crop but you're also saving some by having a winter chemical fallow and I'm certainly getting yield benefits from doing it.

"The other thing is the benefit you get from the livestock. Having green feed over summer means you're fattening lambs and keeping your breeding stock healthy. You have to allocate a benefit to that as well."

Improving the health and water-holding capacity of their soils is also integral to Simon and Cindy's endeavours to bolster their farm's resilience. They have mostly acid sandy soils, ranging from white and yellow sand to sandy gravel with small pockets of loamy sand. Most of their soils have a pH of 4.3 to 5.2 and they treat 300 to 400ha each year with lime to address soil acidity.

They have recently turned more of their attention to how to tackle non-wetting soils, which make up 70% of their property. The non-wetting issue has become more significant with the decrease in clear season breaks with good rainfall.

"When you're getting dryish starts to the season you need wettable soil to get crops out of the ground efficiently."

Simon is a member of the Corrigin Farm Improvement Group (CFIG), which a few years ago evaluated deep ripping and one-way and mould board ploughing as means of ameliorating non-wetting soils.

In the trial, conducted on a neighbour's property, mould board ploughing

SIMON AND CINDY ARE FINDING MOULD BOARDING IS HELPING ADDRESS PROBLEMS WITH NON-WETTING TOPSOIL BUT ARE OTHERWISE NO-TILL PRACTITIONERS, SOWING THEIR WINTER CROPS AND SUMMER PASTURES WITH THIS 12M DBS KNIFE-POINT AUSEEDER.

produced the greatest yield response, and after trialling the technique on their property in 2013, Cindy and Simon decided to incorporate it into their farming system.

The plough is set up to invert the non-wetting topsoil to a depth of 300mm, which also buries weed seeds in or on the topsoil to the same depth.

They bought a second-hand mould board plough in 2014, importing it from the United Kingdom for a total cost of $20,000, less than half the $70,000 cost of a new machine. They have since sold their plough to a former workman who now contracts to them and other growers around the district. Contract ploughing costs about $120/ha, with fuel supplied by the farm.

Simon and Cindy are mid-way through a program to plough all their approximately 1,000ha of non-wetting soil and plan to continue ploughing about 200ha of the property's sandy soils each year.

"With mould board ploughing you get a deep ripping response plus the extra benefits of fixing the non-wetting soil and reducing the weed seed bank," Simon said.

"We've done a number of trials over the years and we've got up to 900kg/ha yield response in a wheat crop in the first year. I've had similar responses in year two as well. You tend to get a first-year kick because moisture in the soil that's never been utilised fully is brought to the surface, but certainly responses carry on."

Paddocks are ploughed in autumn, ahead of seeding, or in September before summer forage stands are sown. Areas to be treated in September are chemical fallowed ahead of ploughing.

"The growth responses we see in summer fodder stands sown after ploughing are similar to what we get with winter crops."

They also apply 2t/ha of lime prior to ploughing to counteract the acidic topsoil.

There are some drawbacks to mould board ploughing, including leaving a rough surface on the paddocks, which usually requires a pass with a cultivator bar and railway line to level the surface ahead of seeding to help ensure good seeding depth control.

Chemical toxicity issues are another consideration post ploughing. "Given that you're bringing up soil that is very low in organic matter and are seeding into very soft conditions there can be issues with pre-emergent herbicides and I have moved away from using any pre-emergents," said Simon.

MOULD BOARD PLOUGHING DOES A GOOD JOB OF SHIFTING NON-WETTING TOPSOIL, AND THE ORGANIC MATTER IT CONTAINS, TO DEEPER IN THE SOIL PROFILE.

"Establishment percentage is also lower in ploughed soil than in an unploughed area because sometimes you get a bit of sealing from having clay on the surface or the bar sinks in so you're seeding too deep. To compensate for that we increase our seeding rate from our usual 70 to 80kg/ha to 100kg/ha in the first year after ploughing."

They use soil survey maps to identify the areas to be ploughed. "Our soil types vary a lot so we don't tend to do whole paddocks," Simon said. "We have ploughed some gravelly soils but sometimes you can't invert the gravels properly and the disturbance stimulates weed germination, so we've got to watch out for that. However, we're still getting responses on those soils."

It is unclear how long the responses to mould board ploughing will last but Simon hopes to see benefits for at least 10 years. "I don't think we'll have to go over it again for some time but I'm not sure how long it's going to last. I think no-till systems increase non-wetting in soils. That's just an observation but I think there's also some data around that."

The next step in their soil amelioration strategy is likely to be deep ripping, which now appears feasible due to equipment advances in the past six years.

"We have a trial going in this year through CFIG comparing the mould board plough, a one-way plough and a deep ripper that works to 50 or 60cm," said Simon. "My thoughts are that we might deep rip the paddocks we've ploughed because we still have compaction below 30cm. I think that will be the next step for us but I want to make sure it works before I go and buy or hire a ripper."

WA growers are also using one-way ploughs to modify their soils and Simon is considering modifying his own one-way plough to use on his gravel soils, where he thinks it might be more effective than mould boarding.

"It's your old Chamberlain or Shearer ploughs that were used mainly for weed control back in the day," said Simon. "Guys are pulling them out of the shed or from under a tree and modifying them. Two WA farmers, Ben and Sean Plozza, have worked out how to put large scalloped discs on these ploughs to ameliorate non-wetting soils. The modified machines do a pretty good job of inverting the soil and can be quite a cheap option in the right conditions."

Simon and Cindy know they have to continue to innovate and adapt if they are to thrive in farming and are capitalising on Simon's agronomy background. They have also made a conscious effort to get involved in trial work and mix with other local farmers through CFIG to brainstorm and test new ideas.

Brothers debunking CTF myths

SARAH JOHNSON

Jamestown grower Luke Clark believes it's time to debunk the myths around CTF and focus on its benefits.

"There are a lot of myths surrounding controlled traffic farming (CTF), including that it's expensive, that you can't have livestock in a system with CTF and that it's too hard," according to Luke Clark.

Luke, a Mid North grower and a director of Australian Controlled Traffic Farming Association (ACTFA), and his brother Scott have been operating a full controlled traffic farming (CTF) system at Jamestown for the past seven years; a period over which they have seen considerable improvement in their cropping enterprise for relatively little expense or effort.

Luke and Scott, together with their respective wives Bernadette and Jainie plus parents Dennis and Mary, operate a 1,680ha grain and sheep business on 1,350ha of cropping land and 330ha of non-arable country.

They moved to controlled traffic farming in 2012 with the aim of improving the efficiency of their cropping enterprise.

"Ours is a small farm for three families to live off so we have to be very efficient with what we're doing," said Luke.

That means finding 'one percent' improvements in their operation wherever they can. "No one thing will provide that 15% gain in agriculture any more but there are probably 15 things you can gain 1% from. That's the theory we work on."

The brothers adopted CTF after taking four or five years to think it through and consider the best approach. And this is Luke's first tip for other growers considering CTF. "For people looking to get into CTF the main thing is to start thinking about it, because getting your head around the concept is probably the hardest part."

He believes there is plenty of information readily available for interested growers. The Clarks found information online – through Google searches and social media – and went on bus trips to see CTF in action.

"It's about looking around at what other people are doing or have done. Social media is a great source of information these days; Twitter is invaluable for farmers. A lot of people put curly questions on Twitter and while you get lots of different opinions, the right answer is usually in there somewhere.

HAVING ALL MACHINERY RUNNING ON PERMANENT WHEEL TRACKS BENEFITS CROPS AND MACHINES.

"Getting off our farm and looking at other controlled traffic farms was helpful too. We went on a bus trip with SANTFA. Everything we've done we've copied from someone else."

Luke's association with ACTFA was another source of information and continues to provide a connection with other CTF growers. "It's just about surrounding yourself with like-minded people," he said. "For me, it's another 10 people to bounce ideas off. You only have to pick up one thing and your involvement is worthwhile."

For the brothers, a key decision in the initial phase of working out CTF was determining the best machinery width for their operation. They chose 10.668m (35'), which allows them to achieve optimal residue spread and provides room for farm expansion. All their machinery runs on 3m wheel tracks.

"Our main concern was the residue spread out the back of the header," said Luke. "We knew that at 35 feet (10.668m) we could get a good spread. We thought 30 feet (9.144m) would be a bit inefficient and didn't give us enough room for growth and we didn't want to go to 40 feet (12.192m) because we weren't sure we could spread the residue that wide."

Residue spread was particularly important because the Clarks grow wheat, barley, canola and beans, with bean residue typically posing spreading problems at harvest. They achieve good spread of bean residue at 10.675m.

Getting the machinery width right from the start is a good way to avoid costly changes in the future, according to Luke.

"The main thing is to pick your width and your wheel track base at the start and stick to it," he said. "Some people start with one width then change halfway through, but that can get expensive. You've got to have a bit of foresight and consider whether or not you're looking to expand in the future and what your capabilities are."

HARVEST MACHINERY IS ALSO ON THE STANDARD 3M WHEEL BASE AND STICKS TO THE TRACKS EVERYWHERE BUT AROUND THE FIELD BINS.

Self-described as 'cheap skates', the Clarks have managed to make the conversion to CTF without a heavy outlay, thanks mainly to purchasing second-hand machinery they had modified by a local engineer. "There's a myth that you've got to spend massive amounts of money to go into controlled traffic. We didn't," said Luke. "Some of the best CTF farmers in the world that I've come across are using 30 or 40-year-old machinery. You don't need the flashiest air seeder to be a successful controlled traffic farmer; you just need to get your head around it."

The Clarks' biggest single set-up expense was a second-hand John Deere RTK auto-steer system they bought from WA for $15,000. "A lot of people run their system off dealer RTK networks but we wanted to control our own destiny," said Luke. "It's a considerable outlay but it's about ensuring coverage. We've got our own base stations and repeater and it means we get a signal everywhere on our farm.

"For us it's peace of mind. You know it's always going to work."

They have either purchased machinery to fit their chosen 3m wheel track base or had machines modified to fit their system.

"We cut and shut a lot of machinery," said Luke, adding jokingly, "Well I didn't. I couldn't weld two bits of butter together."

They used a local engineer to make small modifications, like extending a couple of boom sprayers to fit their standard machinery width and manipulating wheel and axle configurations to ensure machinery tracks on their standard 3m wheel base.

"When we were buying machinery, like second-hand tractors, we made sure it fit our system. One second-hand tractor we bought had narrow axles that couldn't go to three metres so we had to get some wheel spacers made up.

"Our engineer also narrowed an air seeder and I changed wheels around on tractors. That's probably the most qualified thing I am. A tractor-tyre spinner-arounderer!"

Seven years into CTF the brothers are seeing financial benefits from the system, mainly from decreased running costs. With improvements to the cropping soil's friability, there is less resistance to machinery, which has led to reduced diesel costs and less machinery wear and tear.

They operate a John Deere 1890 zero-till seeder and have found less wear and tear on their discs.

"Our tractors are running more efficiently," said Luke. "The fact that the tyres are running on harder ground in the wheel tracks means we're not using as much diesel. And because the cropping soil between the tracks is not being compacted it is much more friable so we get less resistance, less drag with our seeding machinery. It also means we don't get the amount of wear on our machinery we would in a non-CTF system.

"And we're far enough into the system now that we don't have a lot of trouble with it being overly wet. We can get on the paddock sooner after a good fall of rain."

Track renovation to amend ruts on wheel tracks isn't something the brothers have had to worry about during the past two dry seasons, but previously it was an annual operation.

"It's seasonally-dependent," said Luke. "This year we haven't had to do any unfortunately. I like to have to renovate because that means we've had decent rain."

The Clarks share a track renovator with a neighbouring farm; another cost-saving strategy.

In addition to the improved trafficability since adopting CTF, the brothers are also seeing soil health benefits, which are a focus for them.

"Soil health is one of our main profit drivers and our biggest asset. The aim is to hold as much water as we can. We've made improvements in a relatively short amount of time in terms of farming years. Our soil is in a lot better condition now, with a lot better water holding capacity and I think the crops are coming up better, but it's hard to nail that down to just one thing. Is it the disc machine? Is it the stripper front? Is it controlled traffic or using a liquid system? It's hard to quantify."

For the Clarks, it's not just about the impact of soil health now, but also into the future.

"Healthy soil is a healthy farm and it probably goes back to a generational thing. We aim to leave the farm in a better condition to give our kids the best chance to make a living off it. That's if they don't want to be doctors and lawyers."

The brothers have also shown that a controlled traffic system can work on a mixed enterprise farm. They own a self-replacing Merino flock of 500 to 600-head that is grazed on their non-arable land. The business has always had livestock but the brothers moved to physically separate their cropping and livestock land about nine years ago; a decision that had nothing to do with CTF but was taken to ensure they retained residue on their cropping land, Luke said.

"There's a myth that you can't have sheep or livestock in your CTF system but there are plenty of successful controlled traffic farmers around who have livestock. I don't know where that myth came from.

"Separating our sheep from our cropping land had absolutely nothing to do with CTF. It's about keeping them separate to preserve the cover."

Luke also downplays the impact of livestock on soil compaction.

LUKE CLARK CHECKS THE MATURITY OF A CROP OF CANOLA.

That's probably the most qualified thing I am. A tractor-tyre spinner-arounderer!

LUKE AND SCOTT PLACE HIGH VALUE ON RETAINING THEIR STUBBLE.

"Sheep weigh only about 60kg, so they're not going to compact a lot, especially compared to 50 tonnes of machinery rolling around in your paddock.

"Scott and I have toyed with the idea of putting sheep back in our cropping system but at the moment it's not economical to do that."

The final CTF myth Luke is keen to dispel is that it's too difficult to adopt. "We started with autosteer and seeding on the same programmed run lines," he said. "As a result we saw our paddocks were getting wavy and with reduced tillage it started to stand out fairly well. After we did a few bus trips and talked to a few people we realised we were a lot closer to getting our machinery to line up than we thought. I've found that it sort of surprises people how easy it is sometimes to get stuff lined up. It was a natural progression for us."

He recommends farmers considering the practice to start with the online CTF calculator. "You can punch in all of your machinery and wheel base widths and that will show you how much of your paddock you're currently driving over. It scares a lot of people when they see that."

The CTF calculator, produced by Department of Agriculture and Food WA, is available at www.ctfcalculator.org.

Making nitrogen fertiliser

GREG BUTLER

Farmers source synthetic nitrogen fertiliser through a global supply chain dominated by large-scale manufacturing plants using 100-year-old fossil fuel powered technology.

In 2017 those chemical plants, which capture nitrogen (N_2) from the air and react it with hydrogen (H_2) to fix the nitrogen into ammonia (NH_3) collectively pumped out 150 million tonnes of ammonia, 80% of which was converted to synthetic nitrogen in forms useable by plants including anhydrous ammonia, urea and blends such as DAP.

Farmers spend billions of dollars on these fertilisers to access nitrogen originally sourced out of thin air for their crops, yet farms anywhere in the world has access to air and the nitrogen it contains.

So, why aren't we making our own nitrogen fertiliser from air?

Transforming atmospheric nitrogen into a form plants can use is no easy task and for the past 100 years it has not been practical or cost-effective for farmers to manufacture their own nitrogen fertiliser. However, apparatus to achieve the apparently magical transformation of nitrogen gas into compounds that can be used by plants is now being developed on the back of renewable energy projects.

Renewable energy and distributed nitrogen production share a lot of common ground and clean energy innovations such as 'behind the meter electricity' and 'hydrogen fuel cells' are paving the way to green fertiliser and de-centralised nitrogen fertiliser production.

Significantly, the 'disruptive' technologies that will enable farmers to capture nitrogen from the air and convert it into fertiliser are being developed by some of the world's leading industrial and technology companies with the capital and expertise to make this happen.

These developments will enable growers to control their nitrogen fertiliser supply but we are not quite there yet and it is too early to say exactly when the technology will be available or how much it will cost. Moreover, there is likely to be competing methods that fit certain scenarios better than others.

This article describes some existing and new methods for fixing nitrogen from the air into plant-available ammonium or nitrate forms. (Figure 1).

NATURAL NITROGEN

Rhizobia (Figure 1, row A)

Symbiotic biological nitrogen fixation is well known and rhizobia on the roots of legumes are estimated to fix 200 million tonnes of nitrogen from the air into ammonium compounds each year.

The ammonium form of nitrogen is acidifying and soil pH can fall under long-term legume rotations.

Lightning (Figure 1, row B)

Nitrogen is converted into plant-available nitrate form by lightning strikes.

The high energy of lighting explodes atmospheric nitrogen (N_2) and atmospheric oxygen (O_2) into their atomic components, some of which reconstruct into nitric oxide (NO).

$N_2 + O_2 \rightarrow 2\ NO$

This nitric oxide reacts with more oxygen and water and nitrate is eventually formed in the soil.

$2\ NO + O_2 \rightarrow NO_2$

$4\ NO_2 + O_2 + 2\ H_2O \rightarrow 4\ HNO_3$

SYNTHETIC NITROGEN

The rise of renewable energy is stimulating technology and business models that will enable large-scale farmers or collectives of smaller farmers to make their own nitrogen fertilisers using power from renewable sources.

CSIRO figures put the 2017 Levelised Cost of Electricity (LCoE) for renewable [wind and solar-generated] electricity at $80/MWh, with the cost projected to fall further in coming decades. Electricity has never been so cheap if you can work 'behind the meter'. (Figure 2)

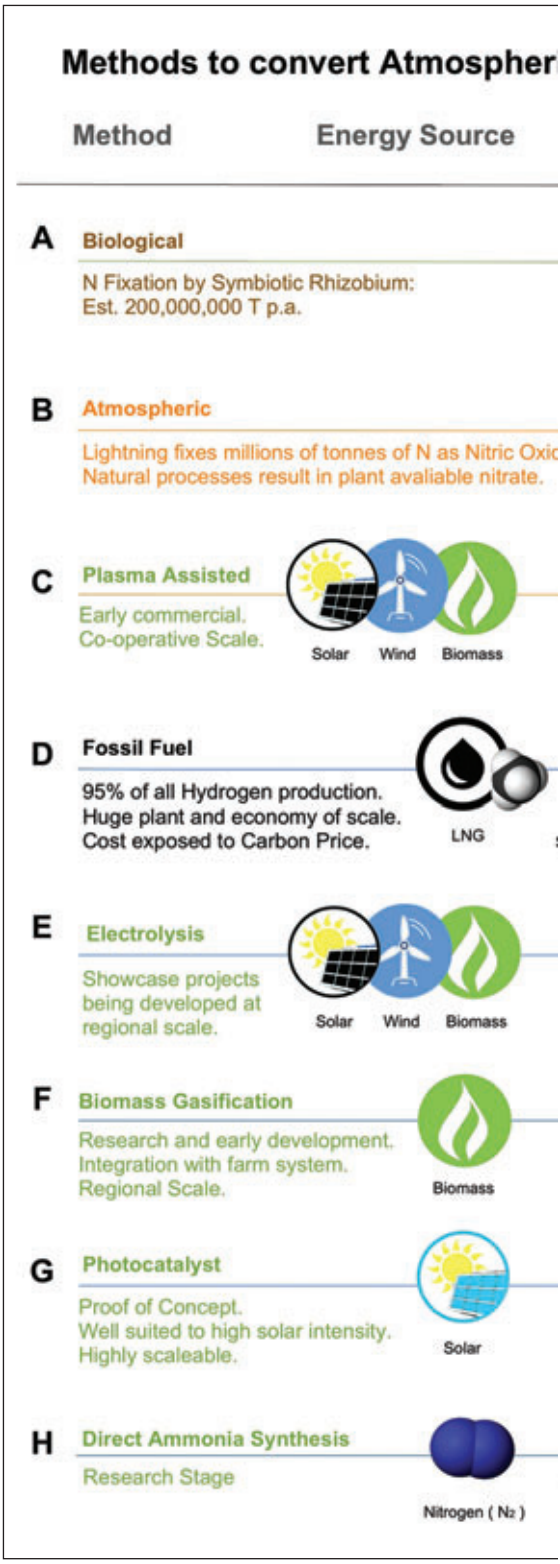
The ability to deploy relatively low-cost renewable energy technologies independently of the electricity grid opens the way to provide energy directly to fertiliser production in regional areas.

Plasma-Assisted N Fixation (Figure 1, row C)

The first example of an electricity-driven process is Plasma Assisted N Fixation.

This process extends back to Henry Cavendish in 1784. It was developed as an industrial process by Birkeland-Eyde in 1903 before it was superseded.

However, plasma and catalytic innovations have progressively improved



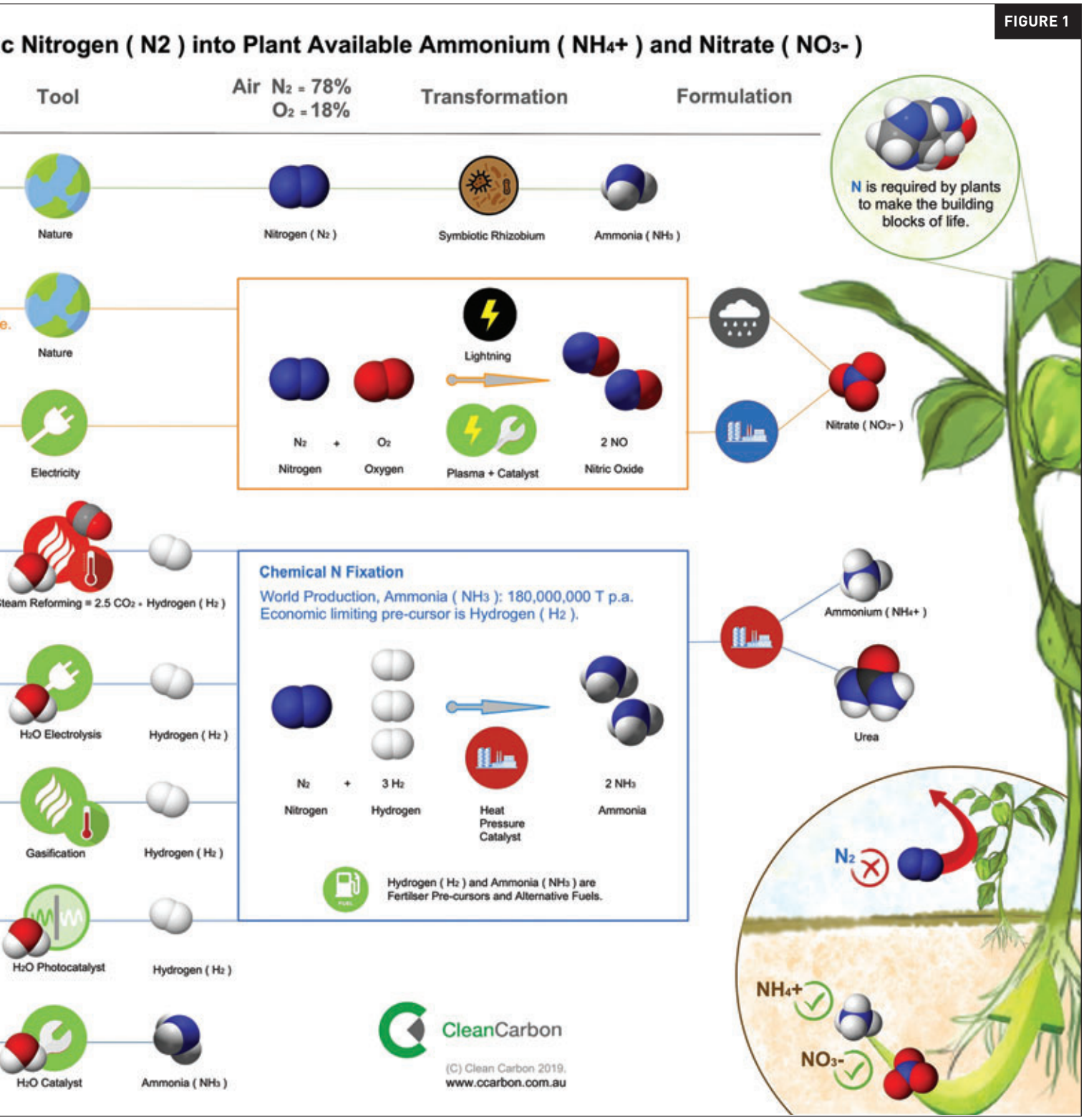
the efficiency of this process over the past 100 years and modern Non-Thermal Plasma has a theoretical energy consumption for nitrogen fixation (~0.2 MJ/mol) that is lower than existing and competitive technologies. (Figure 3.)

In simple terms, Plasma Assisted N Fixation works like lightning to bust apart molecular nitrogen and molecular oxygen and form nitric oxide, followed by further processing using water, oxygen and other substrates to produce nitrate fertiliser.

Use of this technology opens the way for production of nitrate fertilisers including potassium nitrate, ammonium nitrate and calcium nitrate, all of which can be formed using time-tested processes and equipment.

Plasma technology is readily adoptable due to its proposed scalability and simplified back-end formulation options but current thermal plasma demonstration units still have room for improvement and more work is required before this methodology is ready for commercial adoption. These issues are being addressed in a significant international development effort by teams including a substantial research unit at the University of Adelaide.

FIGURE 1



It is important to note that two of the key ingredients used in Plasma-Assisted N Fixation (N_2 from the air, O_2 from the air) are free and carry no freight or inventory cost while water is relatively readily available and very cost-effective to use in this process.

Evonik Industrial has developed a prototype [EcoTrainer] of a containerised production plant that uses Non-Thermal Plasma technology to produce nitrate fertiliser. (Figure 4)

Nitrate uptake by plants results in release of bicarbonate around the roots, which increases alkalinity and raises soil pH. This opens the way for manipulation of nitrogen fertiliser applications to increase, decrease or stabilise soil pH.

Conversely, nitrogen in fertilisers made from fossil fuel is in the ammonium form, use of which results in soil acidification.

Fossil Fuel (Figure 1, row D)

Production and transport of fossil-fuel-derived nitrogen fertilisers generate a significant carbon foot-print that has largely been ignored throughout history, but in the future, such products will be exposed to a price on carbon emissions.

Further, there are real costs for freighting nitrogen over large distances, with profit margins carved up between manufactures, transport companies and distributors.

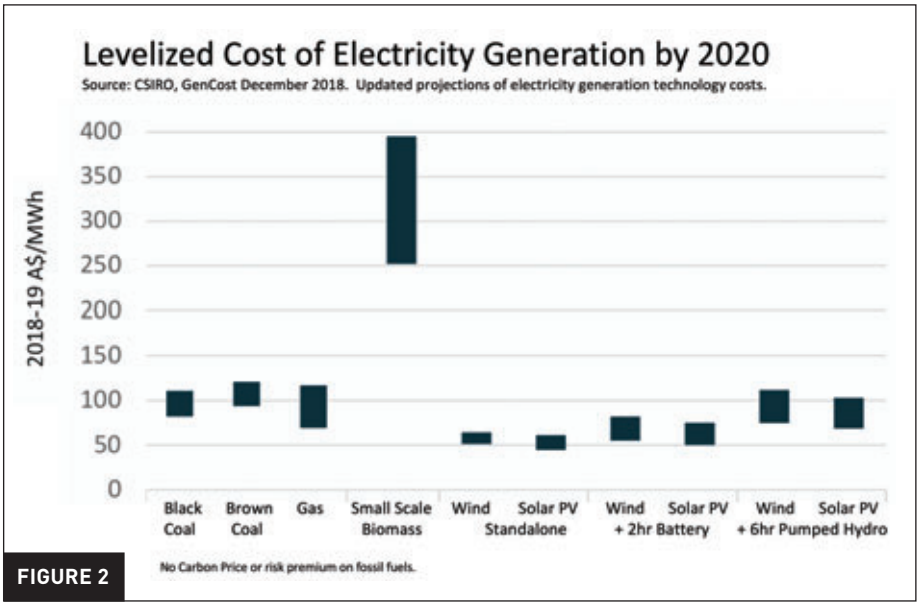


FIGURE 2

Consequently, much of the money Australian farmers pay for nitrogen each year heads off-shore.

Almost all bulk and packaged nitrogen fertiliser is manufactured using fossil fuels in a two-step process.

In the first step, hydrogen (H_2) is extracted from fossil fuel and steam using a high temperature, CO_2-emitting process called steam-methane reforming.

The second step is ammonia production, in which nitrogen (N_2) from the air is combined with hydrogen (H_2) from steam-methane reforming with a catalyst in another high-temperature, high-pressure reaction to form ammonia (NH_3).

$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

Ammonia has been one of the top five most-produced synthetic chemicals for the past 100 years.

Electrolysis (Figure 1, row E)

Hydrogen is the commercial limiting factor in ammonia production. It is currently extracted by steam-methane reforming fossil fuel but can also be obtained by using renewable energy to carry out electrolysis, a process in which hydrogen (H_2) is obtained by splitting water (H_2O) using electricity.

$2\ H_2O \rightarrow 2\ H_2 + O_2$

In recent years there has been major investment by global industrial companies in distributed electrolysis systems to produce hydrogen for hydrogen fuel cell engines.

Because hydrogen and ammonia have roles to play in the fuel and fertiliser supply chains the distributed fertiliser concept has been able to ride on the coat tails of the international investment in hydrogen fuel cell development.

Locally, economy of scale remains an issue for regional ammonia production but the abundance of on-farm renewable energy options could overcome this barrier.

In 2018 Siemens AG, a world-leading supplier of high-tech components, began operations at its Green Ammonia Demonstrator plant at the Rutherford Appleton Laboratory outside Oxford in the UK. The plant is designed to show

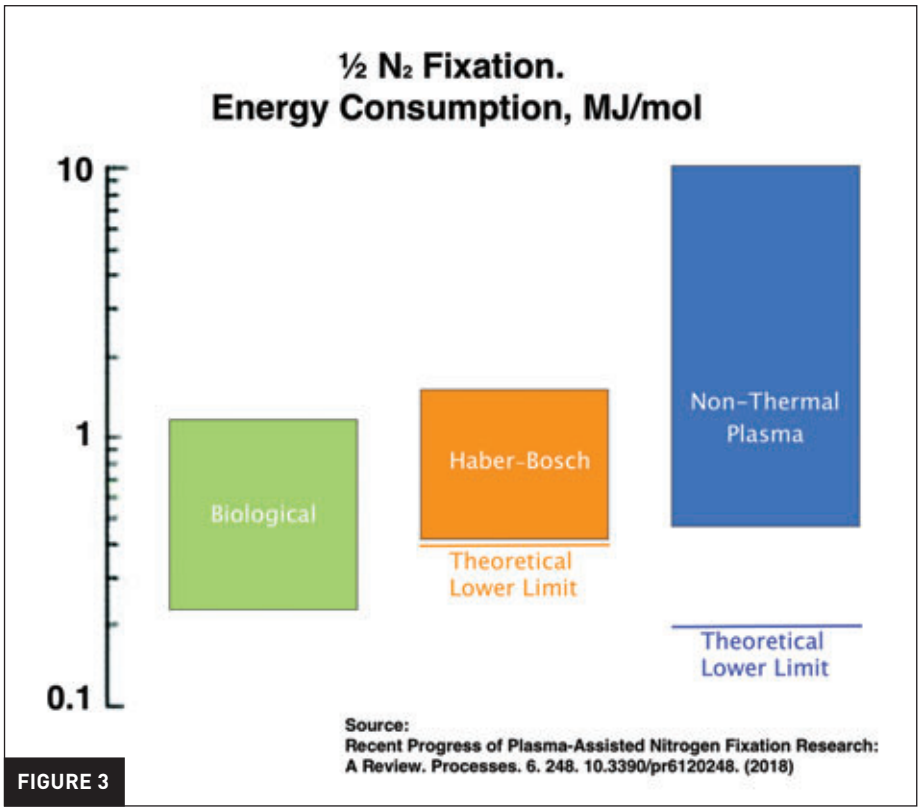


FIGURE 3

FIGURE 4

the complete cycle of renewable electricity generation (wind), electrolysis (for H_2) and ammonia production. (Figure 5)

This technology is still not quite ready for full commercial adoption but the demonstration plant marks a water-shed in small-scale distributed ammonia production. It reinforces the current technical capability, gives a focal point for future process improvement and quantifies the numbers behind the business case.

Moreover, it increases competition. Global industrial company Thyssenkrupp has begun planning a renewable hydrogen and ammonia demonstration plant at Port Lincoln that is forecast to produce 18,000 tonnes of ammonia a year, with most of that contracted to go to Japan as renewable fuel.

BIOMASS GASIFICATION (Figure 1, row F)

Biomass gasification is a method of making hydrogen from materials such as timber residues, straw and other agricultural waste.

Biomass gasification for thermal energy is well advanced but biomass gasification for hydrogen is still some way off on-farm deployment.

In 2015, Safari et al published a research paper showing a hydrogen yield from wheat straw gasification of 6%. This doesn't sound like much but is 60kg of H_2 from a tonne of straw. Ammonia is only 17.6% hydrogen by mass, so 60kg of hydrogen will theoretically make 340kg of ammonia; enough raw material to make 656kg of urea. That is, one tonne of straw could produce 656kg of urea.

Photocatalyst (Figure 1, row G)

New photocatalyst technology, which uses sunlight and a catalyst to split water, is an alternative to the use of electrolysis to obtain hydrogen from water.

Proof of this concept has been achieved and it appears to have low peripheral cost because it does not involve the use of electricity or fossil fuel.

Photocatalyst equipment looks like it will be highly scalable, including to small scale, and reports suggest the technology performs well at high ambient temperature, a significant consideration given high summer temperatures that reduce the efficiency of solar photo voltaic electricity production.

In addition to providing hydrogen for fertiliser production, photocatalyst technology seems likely to be a great fit for cleanly powering remote equipment such as irrigation pumps, since hydrogen can be used in conjunction with liquid fuels like diesel or in a future hydrogen fuel cell engine.

It is not clear how long before photocatalyst technology will be ready for commercial application.

SUMMARY

Ensuring secure supply of essential inputs at reasonable cost is key to any effective long-term business model.

For more than 100 years, large-scale chemical plants have been used to convert nitrogen from the air into plant-available forms that have been sold to growers world-wide. However transportation costs, carbon liabilities, supply chain profit margins and a relentless technology revolution in the energy industry are changing nitrogen fertiliser supply and cost dynamics and creating opportunities for smaller-scale distributed nitrogen fertiliser production.

This seems likely to also offer opportunities to address soil acidification arising from the long-term use of acidifying nitrogen fertiliser products derived from ammonia, with development of new nitrogen production processes such as plasma-assisted fixation enabling farmers to formulate neutral and alkaline nitrate fertilisers to suit their soil pH.

Further, when Australian farmers import fertiliser the revenue flows off-shore. Developing distributed nitrogen production facilities will see millions of dollars stay in regional areas, with significant local community and social benefits.

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FIGURE 5

Managing financial risk in a variable climate

KATHERINE MAITLAND

Western Australian farmer Dylan Hirsch uses a combination of traditional and new risk management tools to protect his business from drought and better manage seasonal production risk.

Changing climatic conditions mean growers will need to find new ways to farm and manage financial risk in the variable production environments of the future, according to WA grower Dylan Hirsch.

Dylan, who is growing wheat, canola and barley in medium to low-rainfall conditions at Latham, in the WA wheat belt about 300km north-east of Perth, has investigated the use of Multi-Peril Crop Insurance (MPCI) and other financial risk products to manage climate risk and how they might influence farming practices.

He says climate change has impacted greatly on the decisions he is making now and expects to make in the near future and has looked into how aspects such as grain marketing, land prices and industry investment impact on his farming business and whether or not a difference in those areas might help reduce overall financial risk.

DYLAN HIRSCH AND HIS FATHER BRAD WITH THE RIPPER THAT IS PLAYING A MAJOR ROLE IN IMPROVING THE PERFORMANCE OF CROPS ON THEIR SAND PLAIN SOILS.

Dylan has a background in engineering, mining and commodity trading that, combined with his knowledge of agriculture, makes him well equipped to take a business approach to his farming enterprise. He is also an optimist who sees every problem as an opportunity; describing variable rainfall as the biggest opportunity in his farming enterprise.

He farms with his parents, Brad and Joanne, and fiancé Kirraly. He has been using no-till farming methods for as long as he can remember, with a shift towards controlled traffic and sustainable farming in recent years.

They have recently improved the performance of some of their sand plain soils by deep ripping and slotting lime to depth to improve sub-soil pH; procedures Dylan rates the biggest improvements to their cropping system in the past 10 years.

"These treatments have enabled crops sown on those soils to access more summer moisture, which has become more critical in recent years, but I think we still have a long way to go with our water use efficiency. We've worked out how to improve our sand plain soils but have yet to find out how we can improve our heavier and gravel soils.

"Further alleviating subsoil constraints should keep boosting our production and if we can get on top of our aluminium issues I think we can expand into pulses and more barley.

"We make lots of mistakes, which I try to record so we can turn them into trials. We're also fortunate to have organisations like [fertiliser and chemical supplier] CSBP and the Liebe [grower] Group that conduct plot trials on our farm. Most of these trials are focussed on nutrition and soil amelioration but there are some herbicide trials planned for 2020.

"We've been farming minimum-till for around 20 years now but have always been full residue retention with minimum tillage. The benefits we have seen from deep ripping our sand plain country in recent years have prompted us to start moving towards a controlled traffic system, but we've still got a way to go."

Dylan believes growers can minimise economic risk by taking stock of land prices and what they can grow sustainably in their local conditions.

"Land is still very affordable and available in our area and frost and fungal disease risk are minimal. We also have access to good lime sources within 200km to address our subsoil acidity."

However, autumn rainfall reliability is becoming very poor so it is critical to take advantage of moisture whenever it is available, he said.

"Our average annual rainfall is 300mm with around 200mm falling in our growing season but with recent climate changes we're now budgeting on 170mm growing season rainfall," Dylan said. "We crop 6,180 ha, which is a typical one tractor, one header operation in our area.

"Long-term profitability is generally good in this district but droughts and loss-making years are frequent. Wide-ranging subsoil acidity makes it hard to incorporate pulses into our system so we tend to stick to cereals.

"We grow wheat, barley, canola and lupins. In the past few years barley has gone from

WHAT HAPPENS IN THE PADDOCK IS CRITICALLY IMPORTANT BUT INTELLIGENT USE OF THE RIGHT RISK MANAGEMENT TOOLS CAN HELP PROTECT FARM BUSINESSES BY REDUCING THEIR EXPOSURE TO A VARIETY OF PRODUCTION AND MARKET RISKS.

being a niche crop to our major cereal. We're also experimenting with a paddock of lentils this year.

"Most of our soils are acidic sand plain, with severe aluminium toxicity at depth in some areas. We also have some more neutral medium red loams.

"Spring heat shock is a concern and we've gradually been moving our season earlier and earlier. We don't have much season length variation in our cereals, growing mostly short to mid season-length varieties, so we sow more canola if we have an early break.

"We try to be ready to sow by March 20, in case of any summer storms, and if there is no autumn moisture will start dry seeding mid-April and finish mid-May.

"If there is a good early break we take advantage of that to increase the area sown to canola.

"We use some expensive RR [Roundup Ready] hybrid canola on planned canola paddocks but keep open-pollinated TT [Triazine Tolerant] varieties on hand to use if the conditions are right for us to sow more canola than planned."

The family recently leveraged their business to buy more land and realised that their extensive use of dry seeding meant they were very exposed to drought risk.

This prompted Dylan to look for ways to future-proof the enterprise and manage financial risk, initially looking to MPCI to protect the business from 'disaster' years and ultimate long-term failure.

"We used MPCI for several years but due to unfortunate circumstances were unable to get coverage in 2017, when we suffered our worst drought on record. This challenged us to look at other options, and in 2018 and 2019 we have used weather derivatives to offset the impact of drought years and insure against our growing season rainfall."

[Weather derivatives are financial products developed around basic variables such as temperature, precipitation, wind, heating degree days and cooling degree days. They differ from insurance in that they require no demonstration of loss, but rather provide protection from climate uncertainty by providing for an agreed payout based, for example, on the level of rainfall variation from the long-term average for a particular period at a specific location.]

Dylan subsequently applied for and received a Nuffield Scholarship supported by the Grains Research and Development Corporation (GRDC) to investigate financial risk management systems. He used his scholarship studies to compare MPCI with other products such as

weather or index insurance products in the hope of finding ways to better incorporate MPCI into his business management plan and identify other business strategies that might complement MPCI.

"The management of seasonal weather variation and opportunity costs arising from seasonal variation is not just an issue for our farm; it affects our entire community," he said. "I was keen to find a better way to help everyone."

One of the findings from his Nuffield study was that there are secondary benefits for farm businesses and local communities when farmers can better manage seasonal production risk.

"Wider adoption of financial risk products can lead to a range of benefits across the agricultural sector," he said.

"Farm businesses are impacted, often negatively, by exposure to seasonal weather volatility. For example, growers are often reluctant to forward sell if they are unsure of their production, even if the price is good. Land is used as security for line-of-credit to farming businesses but leveraging the business to expand in a changing, variable climate can be very risky. Being able to better manage risk can help address all these and other issues.

"Using MPCI can potentially stabilise land prices and give banks reason to back farmers, which reduces overall economic risk and the financial risk of specific businesses, although it might not be just MPCI that ticks the boxes, but a range of business options."

The Hirsch business no longer uses MPCI and the change to other risk mitigation options has involved costs including stamp duty, premiums and administration time. Dylan believes having their current risk management

DYLAN HIRSCH HAS NO DOUBT ABOUT THE IMPACT OF CLIMATE AND SEASON ON HIS FARMING BUSINESS AND AGRICULTURE IN GENERAL, BUT IS CONFIDENT THERE ARE AGRONOMIC AND BUSINESS TOOLS AVAILABLE TO MANAGE THE IMPACT OF THOSE ENVIRONMENTAL RISKS.

mechanisms in place has improved family members' general mental health and, combined with the collection of better farm performance data, given them the confidence to make better grain marketing decisions and expand their business.

"The biggest benefit of MPCI for our business was the confidence to expand our business. It enabled us to make positive business decisions.

"Now we take out machinery insurance that can costs three times as much as we are likely to ever claim. This helps us sleep at night but also enables us to access cheap finance on the machinery. With insurance we can finance machinery for 4% and we are getting 10% return on investment.

"Interest rate discounts haven't really happened here yet but I think they're inevitable. There are finance benefits for users of financial risk management mechanisms in every country with an established risk management program."

Risk management options are worthwhile only if the products are used properly to make businesses more productive and more profitable, Dylan said.

"Poor risk management destabilises land prices, makes it harder to separate land assets from the farm operating business and puts farmers on the back foot when making long-term decisions.

"The best long-term insurance is to have a profitable farm business and maintain strong levels of equity. This will provide resilience to cope with adverse seasons and poor prices.

"We love to pat ourselves on the back for being resilient and good agronomic farmers, but if there are other ways to

manage the risk I think we should look at how we can capitalise on them."

Using a product like MPCI successfully does not always mean making a claim, Dylan said, nor is it a 'silver bullet' to protect a business. Insurance cover enables a business to make better decisions and improve long-term profitability, and the businesses making best use of risk management products such as MPCI are often the least likely to claim.

MPCI is still the dominant climate risk product in developed countries but developing countries like Ukraine, Brazil, Argentina and India are by-passing MPCI and instead starting to use parametric and index products, a path Australia may well follow, he suggests.

"Unfortunately, MPCI products all carry the cost of moral hazard and adverse selection. In simple terms, fraud risk is priced into MPCI premiums and getting a quote requires a robust and often frustrating administrative process intended to ensure the insurer doesn't end up attracting riskier clients. I believe index insurance will inevitably end up replacing MPCI and a lot of other traditional insurance products because it doesn't have the extra expenses that burden MPCI."

[An index insurance product insures against negative rainfall or grain price outcomes, for example, rather than the performance of an individual crop or enterprise.]

"Bureau of Meteorology data is trustworthy, instant and has longevity, so quotes and payouts on weather-related index products can be made immediately and without an assessor. Grain swaps are also essentially an index product. While they don't correlate 100% to our harvest price they're easy to do..

"We hedge our grain sales using swaps up to three years out from harvest. These swaps are converted to physical sales within three months of and during harvest and we try to ensure all grain is sold within a few weeks of harvest, ideally before the new year.

"Index products have minimal administration cost and no adverse selection so premiums are relatively cheap and in WA don't carry stamp duty, which makes a big difference."

The starting point for using insurance products to reduce risk is to know how the risk correlates to the performance of the business, Dylan said. Only then can the manager know what to insure and the level of cover required.

"What works in one place may not work somewhere else. I've got mixed opinions about the US crop insurance program but it has definitely changed the way farming businesses are run in the US. It's amazing to see the level of investment going into farm buildings and improvements compared to what we have here. US farmers will invest in grain storage and plan for 20 years into the future. Without crop insurance there's no way they would make such long-term investments. I can't help but feel a lot of investment and improvements in Australian farms could do with a longer-term view."

Dylan has used rainfall index insurance and weather derivatives successfully in his farming business.

"First, I looked at the relationship between our yield and rain. Plotting our wheat yields and growing season rainfall gave a pretty good correlation and performance line. We used April to October but for other business it might be April-September or something different. You need to check to see which months suit your operation. My standard line of best fit is based on all data but for this exercise I drew another line where I thought we were performing today, based on the more recent yield and rainfall data points," he said.

He then worked out when and how much he wanted to be paid and what costs he wanted to cover.

"In the first year we used our break-even figure as the amount we needed to be paid because it was after the 2017 drought and we couldn't afford to lose money. The break-even figure included all costs, even the price of the weather derivative itself.

"As for how much; each mm of rain is worth something to me. The slope of the graph line [Figure XX] shows I lose 15kg/ha of wheat for each 1mm reduction in rainfall, which is about $3/mm/ha based on a $200/t ($275/t minus cost of freight and harvesting).

In a bad drought he aims to make sure he covers basic repayments, wages, and inputs at $150/ha. "Below 136mm of rain and less yield I'll wear the cost."

Dylan is confident growers can make their enterprises more resilient to climate change by paying attention to their business management as well as their agronomy.

He and his family are using a combination of risk-management tools to protect their business from the financial impacts of drought and better manage seasonal production risk and, with these strategies in place, Dylan is happy to back the business in the long term.

"I think if farmers put as much energy into their business management as they do their agronomy management they would have more resilient businesses that are better placed to take up opportunities which may occur following a drought," he said.

Exploring the value of flame retardant fertiliser

GREG BUTLER*, SEAN MASON**

A fire-retardant chemical high in phosphorous appears to offer several diverse benefits for SA growers.

SANTFA and Adelaide and Mount Lofty Ranges Natural Resources Management Board first explored the potential for use of Ammonium Poly Phosphate Phase 2 (APP2) flame retardant as a fire suppressant in stubble paddocks in 2017 when community and media concern was expressed about fire risks in paddocks with large amounts of retained crop residue.

APP2 has not been tested in the extreme conditions of a real wildfire but controlled burning experiments in 2017 and 2018 showed that it can reduce the intensity of fire across stubble and increase the amount of charred carbon residue remaining on the soil surface after a stubble fire (Figure 1).

The charred carbon residue remaining after APP2-treated stubble is burnt offers some protection to the soil surface but is physically not as durable as un-burnt straw because it is quite brittle, which means it is at risk of being shattered by wheel traffic, hard rain or even strong wind. Conversely, on a molecular level, the charred carbon is chemically very strong and resistant to microbial breakdown.

In addition to fire suppression, using APP2 to reduce the risk of paddock fires or suppress an already burning fire appears to offer other benefits including phosphorous inputs and the sequestration of long-term soil carbon (Table 1).

APP2 and DAP both have very similar N:P ratios and the rate of APP2 required to mitigate fire is equivalent to a high rate of DAP fertiliser.

Phosphorous value

A replicated trial was established on the northern Adelaide Plains to assess the nutrient benefit of phosphorous from APP2 applied to stubble that was subsequently burnt to a charred residue.

In this trial, APP2 was applied to stubble that was then burnt before the paddock was sown to wheat.

At the end of the growing season the soil was sampled (0 – 10cm) by Dr Sean Mason,

FIGURE 1

a recognised leader in understanding soil phophorous, to deterime Colwell P (Figure 2) and DGT P (Figure 3). Both sets of test results showed a trend to higher levels of soil P where APP2 had been applied then stubble burnt ahead of seeding.

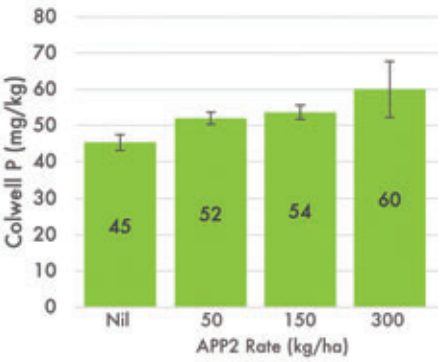


FIGURE 2

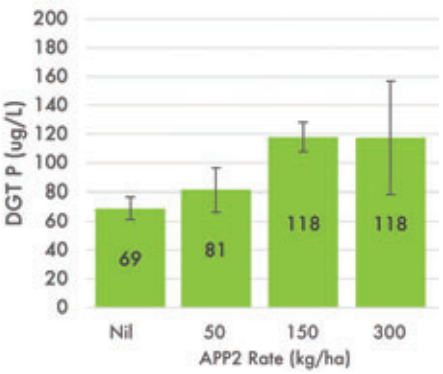


FIGURE 3

These outcomes strongly suggest the phosphorous content in APP2 is not lost when residue spayed with it is burnt. Rather, it seems more likely the phosphorous enters the soil nutrient cycle, so it appears reasonable to think APP2 has an economic value as fertiliser. Howeverr, it is more expensive than regualr DAP phosphate fertilsers per unit of P and its fertilser value goes only part way to justifying its use.

Dr Mason also tested the soil samples from the trial to determine the Phosphorous Buffering Index (PBI) for each APP2 treatment (Figure 4) and found that the PBI where the highest rate

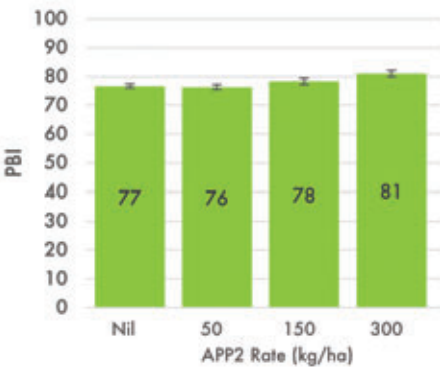


FIGURE 4

of APP2 was applied was statistically greater than in any other treatment. He suggests this could be due to retention of more charred residue in those treatments because carbon products with similar characteristics such as biochar or carbon filter media offer multiple binding sites for a range of substances.

In the soil, an increase in binding sites for nutrients and water generally results in a good outcome.

Soil carbon

Burning stubble releases energy in the form of heat, with most of the carbon in the stubble lost to the atmosphere as carbon dioxide (CO_2). Even when there is no fire, much of the carbon in stubble retained in a paddock is returned to the atmosphere as CO_2 through microbial respiration; that is, the micro-organisms eat the stubble and breathe out CO_2 once they have extracted the energy they need.

Applying APP2 to stubble that is subsequently burnt inhibits the reaction pathway to CO_2 so carbon is retained as char residue that, in addition to offering long-term binding sites for nutrients, provides safe habitat for beneficial soil organisms. For instance, we know from published research[1] that AM Fungi will populate and sporulate in charred carbon habitats, extract phosphorous from the char binding sites and deliver it to the plant.

These binding sites and microbial habitat are the basis of biochar's value. Biochar has been shown to improve soil performance but the cost of transport and the actual product, up to $1,000 a tonne, has limited adoption. A more realistic price for biochar for soil applications is closer to $300 to $400 a tonne.

Burning stubble treated with sufficient rates of APP2 effectively creates a biochar equivalent in the paddock at relatively low cost, which has the potential to overcome many of the existing barriers inhibiting large-scale commercial use of biochar and adds another dimension to the return on investment from using APP2.

The structure of charred carbon residue remaining after burning APP2-treated stubble persists in the soil for very long periods of time. This 'aromatic carbon' has been calculated to have a life expectancy in the range of hundreds of years because it cannot be digested by micro-organisms.

University of Adelaide scientist Dr Ron Smernik conducted a C^{13} Nuclear Magnetic Resonance (NMR) test on charred residue from the trial site and compared the results with the C^{13} NRM of one of the world's leading commercial biochars (Figure 5).

Dr Smernik explained that charring is basically an aromatisation process, with unburnt stubble consisting mostly of carbohydrate (that contains no aromatic carbon), lignin (about 50% aromatic carbon), protein (<10% aromatic carbon) and lipid (no aromatic carbon).

When these carbon forms are converted into a black charred residue most of the carbon they contain is converted to aromatic carbon, a process that occurs along a reasonably consistent continuum, with the relative amounts of aromatic and non-aromatic carbon in a particular char identifying where it sits on that continuum.

Dr Smernik has calculated that the commercial biochar contains approximately 14% more stable aromatic carbon than the APP2 char.

Aromatised carbon is highly stable and is likely to remain in the soil for hundreds of years. Non-aromatic carbon is readily digestible by micro-organisms and will have a much shorter life in the soil.

	Limitation	Benefit	Comment
Product type	Higher-cost way to buy phosphorous		
Placement	Relatively high rate applied at the surface		
Soil cover		More soil cover retained in treated than untreated paddocks	Charred residue is brittle and not as durable as un-burnt straw
Fire risk		Suppression of fire intensity and fire transmission. Effect influenced by application rate	Impact measured in controlled burn but has not been tested in real wild fire
Phosphorous value		Largely retained after burning	Found to be true for most recent trials
Soil carbon: soil health		Charred residue equivalent to biochar	Biochar has been shown to add value to soil but costs and other practicalities have limited adoption. Using APP2 to create biochar in the paddock overcomes many of these limitations.
Soil carbon: sequestration		Long-term soil carbon sequestration	Most of carbon in the char residue will have a lifespan in the soil of several hundreds of years. Is a carbon credit possible?

TABLE 1: CONSIDERATIONS IN USING APP2 AS A FLAME RETARDANT

The graph of aromatic carbon content in the commercial biochar Dr Smernik compared with the char remaining after burning APP2 treated stubble has a symmetrical shape with a large bulge between 110 – 180 ppm with a smaller bulge each side at 10 – 50 ppm and 210 – 250 ppm respectively, indicating most of it is aromatised and unavailable to soil organisms.

The C^{13} NMR graph for the charred APP2 treated residue similarly shows that most of the carbon it contains is aromatised and therefore will remain in the soil for a long period. It also has a distinct secondary peak between 50 – 100 ppm, indicating that a smaller portion of the APP2 treated residue has not been fully aromatised and will be respired by microorganisms.

Sequestration value

The Federal Government's Emission Reduction Fund (ERF) is a means to monetise sequestered carbon. There is currently no ERF methodology that would allow char generated by paddock-burning of APP2 treated stubble but a methodology could be developed.

Chars typically contain between 20% – 50% long-term carbon. The ERF uses carbon dioxide equivalents (CO_2e) to establish values for sequestered carbon, so for APP2 char to qualify for inclusion in the scheme it would be necessary to establish a long-term carbon content value for it and convert that figure to CO_2e.

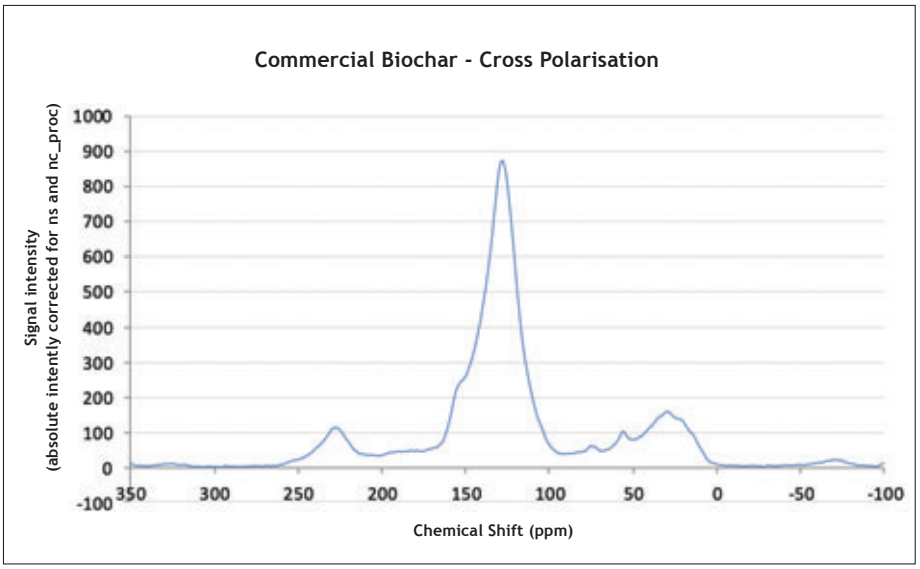
Trial results indicate the CO_2e in a tonne of charred residue generated by burning APP2 treated stubble is between 0.73t of CO_2e and 1.8t of CO_2e. Averaging these values suggests we can assume 1.27t CO_2e per tonne of charred residue.

Using the December 2018 ERF carbon price of $13.87/t CO_2e, each tonne of charred residue could have a carbon sequestration value of about $17.54.

An ERF-acceptable methodology for char derived from APP2 treated stubble could be extended to other burning events such as when paddocks are strategically torched for weed or snail control.

Summary

The cost of APP2 and the application rates required to achieve meaningful fire risk reduction make it a high-cost fertiliser option. However, it has other benefits. Unlike other phosphate fertilisers APP2 delivers fire transmission mitigation, a level of residual soil cover after a burn, soil health benefits through provision of binding sites and habitat for beneficial soil micro-organisms and, potentially, the ability to tap into the ERF to monetise the carbon sequestered in the residual char.



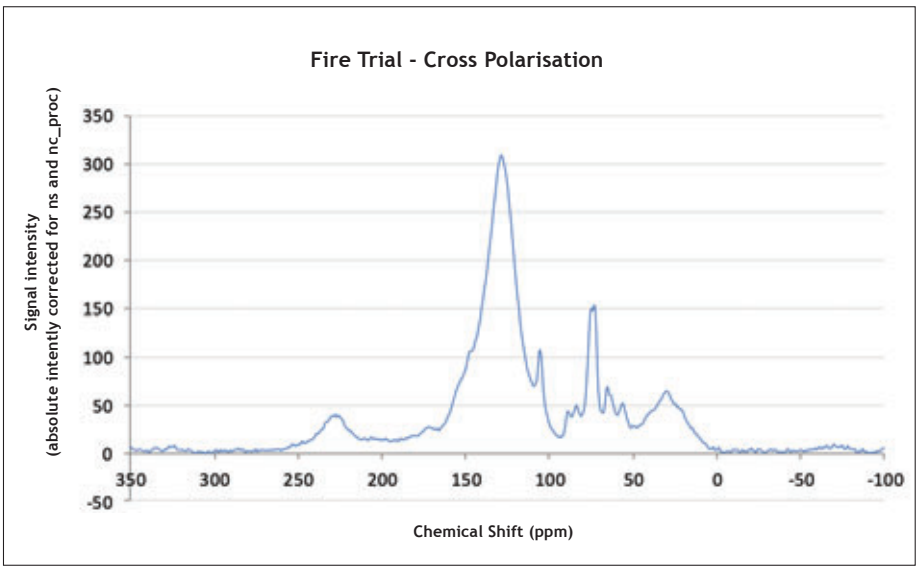


FIGURE 5: THE AREA UNDER THE CURVE OF THE C13 NMR IS A GUIDE TO HOW MUCH CARBON OF A PARTICULAR FORM THERE IS IN THE PARTICULAR CHAR.

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Acknowledgements

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Intensive mixed farming: getting the best from cropping and stock

KATHERINE MAITLAND

Mixed farming still has an important role in Australian agriculture. The question is how to make the most of it and how livestock best fits with intensive cropping.

Canowindra farmer Stuart McDonald has no doubt about the benefits of mixed farming but has moved away from an extended ley farming system to continuous cropping on much of his property.

However, livestock continue to have important profit-generating and risk reduction roles in his business and Stuart believes they can also help improve soil biology and health.

He took the decision to change his farming system and move away from his extended ley (phase) farming system, which is standard practise in the Canowindra district in central western NSW, after he began benchmarking.

"Our benchmarking data showed that the phase farming system we were using – five to 10 years of lucerne and clover followed by five to 10 years of grain crops – was costing us money so we decided to change what we were doing," he said.

At about the same time he received a Nuffield Scholarship to research how best to manage continuous grain cropping and livestock side-by-side in a high-rainfall environment.

"I wanted to see how farmers around the world were running continuous cropping systems and how livestock fitted with those systems to reduce risk, increase returns and improve the resource base," he said.

The findings from Stuart's Nuffield studies suggest that running livestock in conjunction with continuous cropping has the potential to extend pasture productivity, reduce over-grazing, decrease financial risk and enhance whole-farm profitability.

His local experience suggests sowing annual crops specifically for grazing can enhance soil conditions and nutrient uptake by subsequent crops.

In research undertaken in the initial phase of his scholarship Stuart found that since 1995 the proportion of cropped land on Australian farms has increased while livestock numbers have decreased, with cropping and grazing enterprises increasingly segregated. He also found a lot of research into how to optimise performance of extended pasture ley mixed farming systems in his region and trials demonstrating the benefits of livestock to both sides of these systems but little work on continuous cropping in his region.

ON-FARM GRAIN STORAGE ENABLES STUART MCDONALD TO HOLD GRAIN FOR SALE TO LOCAL MARKETS OR TO FEED TO HIS LIVESTOCK.

However, he believes a combination of continuous cropping and good livestock management has the potential to extend pasture productivity, reduce overgrazing, lower financial risk and enhance whole farm profitability.

"I believe there is more value potential from this approach than a simple winter cropping program can provide in terms of dollars per hectare and stability across seasons," he said.

"Continuous cropping, which is not commonly practiced in our environment where high rainfall and good soils lend themselves equally to producing crops or high-quality pastures, will benefit a pasture system when animals can be removed from those pastures once effective grazing has been achieved.

"We have to balance business and financial risk whilst managing differing land classes on the same farm."

Stuart is the fourth generation of his family to run Belmont, a 1,363ha sheep, cattle and cropping business north of Canowindra. Soil types on the family property range from red brown earth through sandy loam to clay loam and average rainfall is about 600mm a year.

He crops 1,050 hectares, sowing mainly wheat and canola plus lupins, chickpeas and oats, and runs a self-replacing 1,000-ewe Merino flock and a herd of 50 stud Illawarra dairy cows.

"We have good infrastructure and are well located for mixed farming. We have a

reliable water bore that supplies our stock water needs and are close to some large users of grain. We have about 1600t of self-emptying on-farm grain storage and one of our neighbours recently had a lime quarry opened up."

Stuart is trialling new varieties of wheat and canola and exploring the potential of chickpeas and lupins with the aim of maximising returns from his cropping program.

"We grow four different varieties of wheat – Wedgetail (trialling Kittyhawk this year) Kiora, Beckom, and Condo – and this year have planted TT 559 and CL970 canola plus HatTrick chickpeas, Mandelup lupins and Planet barley," he said. "We have also sown Greenland forage brassica and Ascend ryegrass for grazing.

"Wedgetail and Kittyhawk are dual-purpose wheats that can be sown from mid-March onwards. Kiora is ideally sown at the end of April, Beckom in the first two weeks of May and Condo from the second week of May onwards.

"Early wheat follows canola in the rotation, with wheat-on-wheat country seeded to a later variety in the second year. The area of each variety is influenced by the moisture available at seeding time. This season there was a good level of soil moisture at seeding so we have sown more Kiora and Beckom. Last year we had a dry start so we increased the area of Condo.

"Wheat and canola, which are reliably high-returning crops for us, are our main crops but they grow over only seven months of the year, with moisture harvesting the aim for the other four to five months. However, I see this as an inefficient use of our high-value land because we get rain in winter and summer and I want to capture and generate income from every drop of rain that falls on our property.

A DRIVER'S-SEAT VIEW OF STUART'S DISC SEEDING RIG HE EXPECTS TO MAKE IT EASIER FOR HIM TO SOW ACCURATELY THROUGH THE HIGH RESIDUE LOADS HE AIMS TO RETAIN TO PROTECT AND FEED THE SOIL.

"We are now aiming to manage residue and plantings so there is no time when the soil is bare and susceptible to degradation, which is also causing us to re-assess our machinery. Our approach has been to accept machinery limitations but I believe this is around the wrong way because it has meant compromising soil conditions. We need to identify how best to protect our soil resource and choose machinery that can help us achieve that."

Working through that issue has resulted in a decision to buy a disc seeder. In recent years Stuart sown his crops with a 12m Flexi-Coil minimum-till seeder fitted with knife points and press wheels but is now using a Morris Razr disc seeder he expects will make it easier to sow into the high residue loads he aims to retain to ensure he captures and retains all the rain that falls on the property and encourage his soil biology and fauna.

"Ideally soil organic matter levels will increase and this will provide fertility and water holding capacity benefits.

"Retaining more residue is central to feeding the changes we are making and disc seeders enable seeding through the high residue loads that protect and feed the soil."

Retaining more residue has so far not improved the performance of his winter crops and in many instances has caused management problems, but he is optimistic that improving soil health will boost the performance of his farming system, although it is not yet clear how best to achieve that in Australian conditions.

"There appears to be great interest in optimising the biological population and capacity of soil, which I feel has been the forgotten leg of the three legs of our soil characteristics; physical structure, chemical and biological.

"The five principles of zero till – year-round living root systems, diversity of plant species, full armouring of the soil and livestock integration – are simple

ideas that can be applied to give tangible benefits to a cropping system.

"These practises are being successfully applied in a wide range of different climatic environments in the US, France and the UK. The principles don't change and in theory can be successfully transferred anywhere, but they don't seem to be directly transferrable to our environment. Applying them here in Australia will require adaption and trialling to see what practises fit our environment and soils and what is possible."

Stuart has been trialling multi-species summer covers and is now looking at companion-planting cash crops.

"We have a farming systems trial currently underway in our cover crop paddocks looking at how summer covers and multi species mixes affect productivity.

"We are two years into trialling how summer multi-species covers might fit into our cropping system and this winter are trialling multi-species grain crops in those paddocks."

He is relying on careful management of an extended rotation to maintain profitability during the transition to his higher-retention, disc-seeding system and exploring other methods to improve his overall farm management and profitability including enterprise-based benchmarking and using agronomy, sheep breeding and nutrition consultants.

"Creating wealth in agriculture is no different to any other business. We are trying to get a clear picture of the profit drivers in the business, set goals and make better decisions.

"We want to utilise a range of selling options to spread marketing risk. With a more diverse range of crop types, wider seeding windows and harvest timing, harvested product either walks out of the paddock as fattened livestock or is carted out as grain."

Stuart's Nuffield Scholarship enabled him to address knowledge gaps around continuous cropping and livestock integration in high rainfall areas and develop approaches he is now applying on his property to grow a more profitable and sustainable business, he said.

"The program appealed to my enjoyment of farming. We had built a toolkit of solutions to our challenges using our experience and the experience of others locally from discussions at field days and farm visits. Being able to then visit farms overseas and see how producers there approached their local issues was a chance to broaden my perspective and recalibrate how I approached farming."

GROWING CROPS WITH DIFFERENT GROWING-SEASON LENGTHS AND STAGGERING SEEDING SPREADS FROST AND HEAT RISK AND INCREASES THE LIKELIHOOD OF ACHIEVING GOOD RESULTS LIKE THIS.

During his overseas study tour he was able to observe the power of grazing used as a tool to improve land, an approach that sees animal productivity as a natural outcome of good grazing management, rather than the primary objective.

His study findings suggest over-utilising pasture can have short-term benefits but negative long-term consequences, with a broader selection of available feed and good management reducing the need to graze pastures beyond the optimum.

This would require running the whole system conservatively with a focus on long-term improvement but would still provide a significant boost in production relative to segregated enterprises, he said, because as the production system increases in intensity, so does the requirement for timely management decisions.

"Focusing on continuous grain cropping, with the integration of livestock, will only work if in the short term it increases revenue per hectare or at a minimum maintains current levels of profitability and improves the resource base.

"All improvements we carry out on our land come at a price and it is easier to reconcile something physical like dragging a deep ripper through a paddock than to identify and quantify incremental yearly improvement in your soil from management or other changes."

He says soil conditions and improvements can be measured by monitoring soil structure using Visual Evaluation of Soil Structure (VESS) methodology, tracking water infiltration rates, using a biological respiration test similar to the American Haney test and carrying out periodic worm inventories.

Economically, all farmers work on margins for profitability and change to an untried system can threaten this, he said, but on-farm trialling and a conservative approach to adoption of new methods can help decrease risk in this area.

"We can't change how our rainfall falls and with what intensity, but it is within our control to have our properties ready at all times to best receive whatever gets thrown at us. This does not supersede my profit imperative; it merely shapes how I go about it.

"I think a whole-system approach to changing what we see as achievable with cropping is needed but this is a longer-term process than a lot of research currently receives funding for.

"Overseas I was often told that the five principles of zero till need to be applied for five years before there will be any major change, but in Australia a three-year research program can be seen as long-term trial. It is also difficult to apply scientific rigour to natural systems and the adaptive, flexible way farmers work because of their dynamic nature, inherent complexity and the number of variables at play, with factors like grazing especially hard to include."

Searching for answers at Thomas Plains

GRAEME JENNINGS

Brendan Ramsey has some of the best-performing cropping paddocks in Australia; he just doesn't know why.

In the National Paddock Survey conducted from 2015 to 2018, three paddocks on Brendan's 1,400ha property at Thomas Plains, on upper Yorke Peninsula between Paskeville, Bute and Kadina, performed better than any of the other 247 paddocks in the survey.

The GRDC-supported initiative saw agronomists and researchers monitor soils and crops on 500 soil-type zones in 250 paddocks from WA to Victoria and up into NSW and Queensland over four years to determine whether or not crops achieved their water-limited yield potential and if not, why not.

The project was prompted by data showing that, on average, Australia's wheat growers achieve about half the water-limited potential yield, notionally 22kg/mm/ha of available rainfall. Its aim was to identify how growers could reduce the gap between potential and actual yields.

Insufficient nitrogen was identified as a common reason for the 'yield gap' on the other YP paddocks in the national survey, with frost and heat shock imposing significant yield penalties and disease, weeds and insects having lesser impacts.

According to Harm van Rees, who presented aspects of the survey at this year's GRDC Grains Research Update in Adelaide, the Ramseys' paddocks 'achieved significantly higher yields than could be explained by either simulation modelling or water use efficiency'.

In other words, the yields on the monitored areas of the Ramsey property were higher than could be explained by standard 'water use efficiency' calculations and greater than Agricultural Production Systems Simulator (APSIM) yield simulations, which take account of factors such as soil type, that were an integral part of the survey project.

APSIM simulations done in an effort to identify reasons for the unusually high yields in the Ramsey paddocks indicated an additional 80mm of plant-available water was required to achieve the yields produced.

BRENDAN [LEFT] AND BRIAN RAMSEY'S FARMING SYSTEM IS ACHIEVING WATER USE EFFICIENCIES IN SOME PADDOCKS THAT ARE PROVING DIFFICULT TO EXPLAIN.

Australia's wheat growers, on average, achieve about half the water-limited potential yield, notionally 22kg/mm/ha of available rainfall.

The researchers heading the Paddock Survey are, like Brendan, struggling to find reasons for what they measured but have suggested 'access to deep soil water' as a possibility, which from a farmer's perspective would appear to point to greater than usual root depth.

Brendan is inclined to attribute the results to the fact that his property is usually unaffected by frost and he has machinery that, while probably bigger than he really needs for his 1,400ha, enables him to get his crops in 'on time', usually between May 5 and May 25, and the grain harvested and into storage as soon as it is ready.

His regular use of poultry litter may also be a factor, as could the fact that he monitors his crops closely and is set up to react quickly if it becomes evident he needs to spray to address a problem, particularly with fungus disease in his lentils.

The long-term average annual rainfall on Brendan's property is 380mm and the average wheat yield over the past 10 years is about 3.5t/ha, with wheat yields on some sandy rises as high as 7t/ha in some seasons since he began spreading poultry litter.

His 10-year barley average is about 3.5t/ha and lentils generally produce around 1.6 t/ha.

Land prices on upper Yorke Peninsula mean Brendan, a member and former president of the Paskeville Agricultural Bureau, needs to 'squeeze all I can' out of the area he has and, in addition to his continuous cropping program, he buys in and finishes lambs on an opportunistic basis, using a combination of lot feeding and stubble grazing to grow them on to market weight.

While he has a clear focus on the agronomic 'basics', including timely seeding and harvesting, and the economics of what he does, Brendan is always on the lookout for ways to improve his cropping performance, as was his father Brian, who

is still involved full-time with the business.

Until the 'arrival' of lentils as a viable SA crop about 20 years ago they were using a flexible rotation of two years of cereal followed by one of legume but with lentils now an established part of the cropping program Brendan has settled into a cereal/legume/cereal/legume cropping sequence that he varies as needed to address factors including market demand and prices, seasonal and paddock conditions, weeds and diseases.

"There are different issues every year but things tend to work themselves out."

Growing lentils on each paddock every second year means he can use clethodim in crop to control grass weeds, particularly annual ryegrass, as needed and having 'Clearfield' varieties in his cereal repertoire opens the way for in-crop control of broad-leaf weeds and some grasses in the cereal phase if necessary.

His sprayer is a self-propelled John Deere 4940.

Brendan and his father tried beans and chickpeas in their search for a legume break crop but have settled on lentils as the best pulse fit for their conditions and farming system. And the economics are right too.

"The returns from lentils make them simply too good to ignore and they are a good agronomic fit," Brendan said.

"Back in 1996 or '97 dad was one of the first in this area to grow lentils and now they are main-stream.

"In those early days we didn't do a lot to them; just sowed them and let them go. Then we worked out they would perform and yield much better with a bit more attention.

"These days we continuously monitor them, mainly for disease, and in good year when they grow a big canopy we can apply three or four fungicides. However, with our set up there is still money to be made from them.

"They really do require a lot more work than cereals and I know of a couple of growers who have decided they are just too much trouble, but they work well for us."

Brendan moved away from barley for several years after he began using poultry litter because it made the soil too 'rich' for the varieties he was growing, resulting in serious lodging because of excessive growth early in the season, which also led to several crops with high levels of pinched grain because the strong early growth used up too much water early in the season.

The combination of crops lying on the ground and poor-quality grain meant barley simply wasn't profitable. However, the attributes of some recently released barley varieties are putting barley back on the Ramseys' cropping agenda.

Brendan initially tried Compass but found that he needs to apply a growth regulator to control its early vegetative growth and even then it still has a tendency to lodge. He is still growing some Compass but is finding that Spartacus, a shorter-strawed, early-maturing Clearfield variety, seems better able to handle his nutrient levels and growing conditions and is producing yields that are making barley production profitable again.

Brendan finds the 'birds-eye view' images very revealing and of more value than yield maps to pinpoint where to rip.

While Spartacus and Compass are both malting varieties Brendan is not pursuing that market, preferring to focus on maximising yield and protein and delivering his grain for feed price to Wallaroo, his closest receival point. If he wanted to have his grain considered for malting he would have to truck it further to a receival point with segregation capability and the extra transport cost would be greater than the malting premium he might receive.

Brendan and Brian began exploring the potential of poultry litter as a manure in 2006, initially spreading some on a sandy rise to see if it would improve the performance of crops on that soil type, which was not producing as much as their heavier flats country.

They had some left over after applying the planned rate on the trial area so they used GPS-linked yield data to spread the left-over litter on several areas of heavier soil the yield maps indicated were yielding below the paddock average.

Two years later Brendan noticed some 'crazy' yields from apparently random patches in paddocks he was harvesting and after an initial 'what's going on?' reaction, tracked the phenomenon back to the litter application two years earlier. Yields from areas where the litter had been spread were well over the paddock average and way up on what they had been producing previously.

It was at that stage they realised the litter, which is now applied with a 24m^3 capacity Brochard Dragon spreader, was providing a clear benefit and decided to begin using it over the whole property, not just on the sandy rises.

They have settled on a standard rate of 3t/ha that is applied a month or so ahead of seeding to the 700ha to be sown to cereal that year. If there is any surplus remaining after the scheduled application program it usually goes onto one of the sandy rises, with some of their sandy country receiving up to 9t/ha in some years.

The combination of nutrients from the litter plus nitrogen fixed by the lentils in the previous year provides most of the cereals' nitrogen requirements and means Brendan doesn't usually need to apply any 'starter' fertiliser at seeding.

That appears to have little effect other than his crops getting a little slower start than some of his neighbours', he said, but that changes once they start to develop their secondary roots and can access more of the nutrient available throughout the topsoil.

However, he did apply a 'starter' rate of DAP with the seed this season to compensate for the low rate of nutrient mineralisation due to the dry conditions that limited activity of the soil organisms over summer and autumn.

Brendan is aware that consistent application of poultry litter is likely to improve soil organic matter levels and soil health but at this stage he is more interested in its nutrient content and ability to directly improve crop performance and has seen a clear increase in grain protein levels and a less consistent rise in grain yields since he began spreading poultry litter annually.

The litter is delivered to the property by the company that has a contract to clean out nearby poultry sheds. The company provides an indicative nutrient analysis of the litter each year and, since the product is usually quite consistent, Brendan uses that analysis, in conjunction with soil test results and in consultation with agronomist Stefan Schmidt, to work out whether or not he needs to apply any additional nutrient.

BRENDAN RAMSEY USES A COMBINATION OF 'VISUALS AND SCIENCE' INCLUDING CURRENT JOHN DEERE PRECISION AGRICULTURE TECHNOLOGY TO MAKE AND IMPLEMENT AGRONOMIC DECISIONS.

He has a comprehensive soil testing regime that includes annual deep soil tests for nitrogen and precision tests for a range of nutrients at 10 sites across the property to check that he is not 'mining' his soil and running down basic soil nutrient levels.

Results from the latest series of tests suggest he is 'on track' and not adversely impacting his soils, with his nutrient levels holding OK, but he has so far not seen any clear evidence of an upward trend in soil organic matter levels. He is, however, finding that his lentil crops seem to be healthier, less susceptible to attack by fungus and other diseases and to be producing bigger canopies than was the case before he started using the poultry litter; although that is based on field observation, not hard data.

His lentils, like the cereals, are sown on 250mm row spacing, which has been Brendan's standard spacing for the past 10 years or so.

Brendan has been direct drilling for more than a decade – his current seeder is a Bourgault 8910 five-row cultivator bar fitted with Atom Jet knife points – but is not afraid to work soil if necessary to address a specific issue and has begun deep ripping his sandy rises, something his father was exploring before Brendan took on responsibility for the property.

"The issue is a hard pan at depth, around 50cm in most areas but deeper in some places and shallower in others. It appears to be an inherent characteristic of the sandy loam soil on the rises rather than the result of machinery compaction.

"Dad was always experimenting and trying things and started ripping our 'sand hills', which are really only sandy rises, with a single-tine rabbit ripper years ago.

"A few years later, when I realised the

strips of better crop we were seeing in our sandy paddocks were growing along those rip-lines from years earlier, we bought a five-row sub-soil cultivator from an Adelaide Hills potato grower and started playing around with that.

"That was about the same time as we started spreading poultry litter.

"We found that, after a pass with the five-row and an application of poultry litter, we would get great crops for a year or two then the yields would start to tail off again, so about three years ago I bought a new AgrowPlow specifically for deep-ripping the sandy rises.

"The five-row was really impractical for our scale and application. The AgrowPlow is purpose-designed and considerably wider than the five-row so it does a good job when the soil conditions are right and its size means we can rip a larger area in the time available.

"The first year we had it we had lovely conditions with good soil moisture in February and March so we were able to open up an entire paddock and saw amazing benefits from that in the following crop, which has prompted us to really start to investigate what might be practical and whether or not we can safely push the system harder by increasing seeding rates, for example.

The attributes of some recently released barley varieties are putting barley back on the cropping agenda.

"This year the soil was so dry we couldn't get the tines to penetrate to working depth, so it's pretty clear that ripping will be opportunistic because we can do it only when the soil conditions are right, and at this stage it is too early to know how long the effect will last."

While the AgrowPlow was bought specifically for use on the sandy rises Brendan did take it down onto a flatter paddock with heavier soil with the idea that there might be benefits from opening up those soil types too, but there were simply too many rocks for the machine to handle.

Agronomic decisions are based on a composite of data from measurements including yield maps and soil tests and visual assessment, which has recently been augmented by 'visual' images – not infra-red or NDVI – from a drone-mounted camera.

"We use a combination of visuals and science," Brendan said. "If I notice anything unusual, particularly in terms of crop performance, I always try to back up the observation with data by going back to measurements or test results from that area."

He is finding the 'birds-eye view' images of what is happening in his paddocks very revealing and of more value than yield maps for targeting ripping, in particular.

Brian and Brendan have been yield mapping since the late 1990s and were among the first growers in the district to have a header with an integrated yield monitor. Their current header is a John Deere S680 fitted with the company's current-generation precision agriculture and yield monitoring technology but Brendan finds yield maps are not quite accurate enough to pinpoint where to rip.

"By September you can clearly see differences in crop growth from the air and I can use those images to work out exactly where action is needed. I can see where I have improved the situation and areas I need to rip. If I see a distinct edge to 'good' crop where I have ripped I know I stopped too soon and didn't work far enough down the slope."

Brendan has recently begun using the AgWorld farm management platform to collect and collate data, which in addition to ensuring he has accurate, readily retrievable records of chemical usage and similar, enables agronomist Stefan Schmidt, who is also linked into the AgWorld system, to access all the relevant farm and business and data when developing recommendations for the Ramseys' enterprise.

His on-going search for ways to refine or improve what he is doing has also seen him sow some of his later crops this year with a liquid delivery system, which he used to apply trace elements with the seed at sowing.

Brendan finds his current method of applying Impact fungicide to the seed ahead of sowing time-consuming and messy.

While he used trace elements in his fluid application trial and sees potential to use it for application of 'starter' fertiliser if required, Brendan's interest in the technology is being driven by his search for a better way of applying Impact fungicide.

He finds his current method of applying the chemical to the seed ahead of sowing time-consuming and messy and is hopeful that, if the economics and practicalities prove out, he will be able to use liquid application technology to deliver the fungicide direct to the furrow during the seeding pass; an approach that appeals as simpler, cleaner and more efficient.

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