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SANTFA
CONSERVATION AGRICULTURE IN ACTION

The Cutting Edge

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More to perennial cereals than yield page 24

Covers, litter and the terms of trade page 20

Weed wrangling, Mallee style page 8

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Contents

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President's Report

"There is no better than adversity. Every defeat, every heartbreak, every loss, contains its own seed, its own lesson on how to improve your performance the next time." - Malcolm X

Drought and frost presented many frustrations during 2018. But if we are to look for a silver lining – and I'll admit you may have to squint pretty hard to find it – the year also presented some valuable lessons for how to improve our performance in dry years to come.

The less than desirable start, with much of the State receiving little to no rainfall before April/May, showed the importance of stubble management at harvest. It also demonstrated the need for even groundcover over paddocks to retain as much moisture as possible while enabling timely sowing. Frost became a big leveller during spring but those who managed to get crops up evenly were well rewarded, capitalising on a better hay cut and achieving more profit.

We are already putting aside the hardships of last year and turning our focus to what we hope will be a more successful 2019.

Here at SANTFA we are planning a great line-up of speakers for our annual conference, on March 1 at the Barossa Arts and Convention Centre, Tanunda.

Thomas Foods chief executive officer Darren Thomas, who will headline the conference, will give his expert opinion on the future for livestock, providing vital insights for growers considering re-entry into mixed farming enterprises. He will also reflect on last year's devastating Murray Bridge abattoir fire and the rebuilding effort that is still underway.

We also look forward to hearing from US speaker Dwayne Beck, from Dakota Lakes Research Farm, NSW cotton farmer David Ricardo, Eyre Peninsula farmer and rural health advocate Michael Hancock, Rural Directions agribusiness consultant Simon Vogt and SANTFA's own R&D manager Greg Butler.

I wish to thank Sam Venning, who finished his term as SANTFA president at our AGM last year, for his service as president. Sam stays on as past president for this year, offering guidance and support as I take on the reins. We farewell outgoing board member Ben Pope and thank him for his contributions, particularly during his time as treasurer, and welcome Minnipa farmer Gareth Scholz to the board.

Looking forward to seeing you at the conference. Be sure to book your spot early so you don't miss out.

Callum March

Farming 101 – keep it simple and focus on the basics

SARAH JOHNSON

Jason Berends learnt the hard way that simple is best. His advice to young farmers is to concentrate on getting the basics of timeliness, nutrition and weed management right first.

Jason and Jen Berends are putting their faith in simple farming.

After suffering the consequences of seeding delays and machinery issues over several years, the mixed enterprise farmers three years ago resolved to re-focus on getting the basics right on their YP property.

This has meant ensuring their crops are sown on time, reducing livestock numbers, removing canola from their rotation and investing in a simplified disc seeding system.

Jason believes the three cornerstones of farming are timeliness, nutrition and weed management. Only once these are achieved should growers consider adding diversity or experimenting in other areas, he suggests.

"Once you are able to do everything on time and you've got your nutrition and weeds right, then you've got the foundation to start introducing a diversity of crops and widening your rotation or even taking a multi-species cover crop approach.

"I haven't completely nailed these things but we're getting there and have made some big improvements. I think I was guilty of trying to nail the two per cent stuff rather than nailing the 80 per cent stuff."

JASON BERENDS IS SEEING THE BENEFITS OF SIMPLIFYING HIS APPROACH TO FARMING TO FOCUS ON THE ESSENTIALS.

A CHANGE IN DISC CONFIGURATION AND ROW SPACING PLUS THE ABILITY TO DELIVER LIQUID NUTRIENTS HAS IMPROVED SEEDING-TIME PERFORMANCE, WEED CONTROL AND CROP HEALTH AND PERFORMANCE.

Timeliness is at the top of the Berends' must-do list and they now sow in April; three to four weeks earlier for some varieties than in the past.

"For the past three years we've started sowing in April, whereas before it might have been the end of the first week of May or even the middle of May," said Jason. "I remember years ago not starting until the 23rd of May because I was messing around with machinery. Now we're starting three to four weeks earlier than that. It's no wonder we're getting better results."

Seeding delays that cost the Berends' yield and profit were the trigger for their decision to simplify their farming system.

"2011 was the year that pushed us over the edge. We saw the difference that sowing two weeks later can make by the end of the season. It can halve your yield, especially in a dry year on shallow country. That year my next-door neighbour sowed wheat in the paddock right alongside us a fortnight to three weeks' earlier than our crop went in. At harvest time his paddock yielded 50% more than ours. He reapt 3.6t/ha and I reapt 2.4t/ha.

"At the time I thought we're not going to be farming for very long if we keep this up. A 50% yield difference is huge. We might have broken even that year, while our neighbour made a profit. It really hit home that you just can't mess around with this stuff."

Machinery issues were the main cause of seeding delays for the family, who moved from a tine set-up to a self-built disc seeder in 2008. In hindsight, Jason believes sticking with a familiar system would have been a better option.

"We probably pushed down the disc path a bit prematurely and tried to cobble

things together ourselves all in the name of saving money," he said. "In the early years we were always building or modifying something before we went seeding and therefore suffering a time penalty. I wouldn't recommend anyone mess around trying to build something that costs you time. Without being silly, just get a chattel mortgage and buy what you need, which is what we eventually did. We bought a proper seeder on finance and that paid for itself. That was a step forward for us."

Jason and Jen's 1,050ha mixed enterprise farm, 12km south of Yorketown, was previously Jen's family farm, run by her father Geoff Davey, who is now retired. Prior to joining Geoff at Yorketown the couple spent seven years on Eyre Peninsula, which is where Jason, an apricot grower's son from Loveday in the Riverland, 'learned the ag trade'.

"I did a seven-year apprenticeship at Cummins and then we got the opportunity to come back and start share-farming Geoff's property."

In their second year at Yorketown they increased the size of their holding with land leased from Jen's aunt; an expansion that meant they needed a bigger seeder than the 27-row Shearer Trash Combine fitted with knife points they had been using and prompted the decision to change their seeding system.

The Berends' bought disc modules and Jason built the seeder. "I should have kept it simple, but instead I was trying to learn how to manage a farm while also learning a new seeding system," he said. "We've had another two changes of seeder since then. After using the self-built disc in various forms for three years we ran a K-Hart disc opener for another three years before buying a Serafin single disc seeder."

THE PROOF IS IN THE HARVEST. THIS IMPRESSIVE WHEAT CROP IS TESTIMONY TO THE EFFECTIVENESS OF THE BERENDS FAMILY'S 'SIMPLE IS BEST' APPROACH THAT HAS SEEN THEM PLACE TOP PRIORITY ON THE BASICS OF TIMELINESS, NUTRITION AND WEED MANAGEMENT.

They operated the Serafin seeder for four seasons before fitting the bar with Alpha discs, designed by innovative WA grower Mic Fels, which they have used for the past two years. "Going with our simplicity theory, the Alpha discs are a very simple seeding arrangement," said Jason.

Their nine-metre converted disc seeder is set up to sow on 190mm row spacings, a significant reduction from the 305mm spacing on the Serafin in its original configuration that has provided improved weed competition. "I was surprised by the level of weed competition we get with the narrow rows," said Jason, whose initial motivation to reduce the row spacing was the number of sheep he was running at the time. "I saw the difference last year and I thought sheep or no sheep, I'm staying on narrow rows. It's just another tool in your toolbox as far as weeds go.

"It's really about what happens later in the season. For example, if some ryegrass gets through your pre-emergence chemicals in a wheat crop, by springtime on a 305mm row the weeds are quite sizeable and have a lot of tillers. With narrow rows the ryegrass tends to get shaded out and is less vigorous and you end up with much smaller, more feeble plants in the inter row."

Jason also believes that using the Alpha discs has improved the efficacy of pre-emergence chemicals like Boxer Gold and Sakura due to improved incorporation. The Alpha design means there is some soil disturbance because the set-up doesn't include a gauge wheel to hold the soil down.

"That little bit of extra soil throw with this machine has made the pre-emergence

chemistry work far more effectively. I was discussing this year's pre-emergence chemical plans with my agronomist a few weeks ago and I've let him budget for the expensive pre-emergence chemicals, which I've never let him do without a fight before.

"I used to be really sketchy about spending money on expensive pre-ems because if you're talking $40/ha you really want to see some value for that money. I'm finding that the combination of extra soil throw and narrow rows means we're getting much more effective use out of them."

The usual grass weed suspects – ryegrass and brome grass – are problematic for the Berends but since reintroducing lentils into their rotation they have noticed an increase in Indian hedge mustard, a broad leaf weed. "Broad leaf weeds in lentils are probably more concerning to me than grass weeds now," said Jason.

He and Jen are tackling their emerging broad leaf issue by doubling the number of broad leaf sprays in their cereals to reduce late broad leaf weed emergence ahead of following lentil crops and adopting chaff lining to achieve some control of weed seeds at harvest.

Their crop rotation is approximately one third each of wheat, barley and lentils, with the exact ratio depending on agronomy decisions and price indicators. Lentils have replaced beans and canola due to the poor price of beans and snail issues with canola. Beans provided a good foundation for growing a profitable canola crop the following year but the returns from beans were low and the cost of sowing and growing canola didn't add up for them in the end.

SPREADING CHICKEN MANURE ON FORMERLY 'POOR' CROPPING GROUND HAS PRODUCED IMPRESSIVE RESULTS, LIFTING YIELDS ON THOSE AREAS TO MATCH THOSE FROM JASON'S MOST PRODUCTIVE LAND.

"The extra dollars required just to grow the canola crop put me off," said Jason. "There's a reasonable amount of canola in our area because of the mild climate and a 3t/ha yield is not unheard of so it can be a valuable part of your rotation, but when you're doing your budget and see that you need an extra $30,000 to put a canola crop in, the answer was eventually 'no'."

The Berends have also struck problems with ***Pratylenchus*** nematode, which Jason considers one of the farm's biggest constraints. This pest, which is hosted by canola, affects a broad range of crops including wheat, with what looked like nutrient deficiency symptoms turning out to be caused by ***Pratylenchus***. "A few times I'd have under-performing cereal crops, and when we dug up a plant and looked at the roots, ***Pratylenchus*** was the issue. We were finding more damage from ***Pratylenchus*** than from ***Rhizoctonia***, so in the end it was relatively easy to make the decision to drop canola from our rotation and start growing lentils again."

Jason has delayed any strong push towards diversity in his rotation, apart from experimenting with some millet in summer.

"We need to have a hard look at diversity going forward but it's a case of simplifying and streamlining our operation first, to make everything work well, which will create some space in my head to tackle things like diversity properly. I'd rather not introduce something else into the equation if I can only do it with a half-baked approach and not get the results I need to."

The desire to simplify their system also triggered a decision to reduce livestock numbers.

Jason introduced sheep in 2012 as a strategy to spread risk in case of drought and built the flock to 750 ewes. He has now reduced that number to 400.

"For me it was an easy decision to strip the sheep enterprise right back so it basically becomes a hobby, leaving us to concentrate on making the cropping side

THE BENEFITS OF NARROWER ROW SPACING, TIMELY SOWING AND GOOD SEEDING-TIME NUTRITION ARE CLEARLY EVIDENT IN THE PADDOCKS.

as efficient as we can. With the larger flock I found there was a constant compromise between cropping and sheep and I'm naturally more inclined towards cropping. It was frustrating me that I wasn't doing cropping work because of the sheep and ending up playing catch-up."

The decision to reduce flock size was made easier by the prices being paid for sheep when he was considering how to proceed.

"Prices for sheep are quite good at the moment, and for me that sounds like an awesome time to get out. We sold 350 ewes in late 2017 and people said, 'you're mad, why are you getting out?' I was like, 'everyone gets out when sheep are worth nothing, I think it's the perfect time to sell them'."

Jason's adoption of a liquid injection system to apply cropping nutrients runs counter to his 'simplicity' mantra, but the results outweigh the complexity the liquid system adds.

"It's worth it. It adds a layer of complexity and it's anti keep-it-simple but we need to grow a healthy crop to achieve a profitable crop. I just decided we were missing out on some early crop health from not having the liquids there at seeding, so we dragged the air seeder box up to the engineer and asked him to put a tank on the front."

That was three years ago, when they switched to the Alpha discs on the Serafin machine. In addition to the change in configuration they added a friction flow tube liquid nutrient delivery system to the seeder at a cost of about $10,000. It is used to inject trace elements – zinc, manganese and copper – plus Flutriafol fungicide.

"There's nothing fancy about the system; we just put it together with bits we had lying around," Jason said. "Getting the tank installed on the seeder was the dearest part because the seeder box chassis had to be modified to accommodate the tank.

"I think using the liquids has helped with root disease and has definitely improved early crop health. We're just seeing a healthier plant. In the past I was going out in the paddock and wondering what to throw at it. Now I'm going out and looking at healthy crops."

Spreading sulphate of ammonia across their property has been another game-changer for the Berends' crop health. "A mate down the bottom end of the Peninsula who was hardly getting a crop to cover his sand hills started playing around with sulphate of ammonia at various rates," said Jason. "Visiting his farm and seeing the crops over the top of sand hills after he'd applied sulphate of ammonia was really inspiring, so I thought I'd try some.

JASON IS FINDING THAT THE SOIL THROW FROM HIS ALPHA DISCS, COMBINED WITH CLOSER ROWS, HAS IMPROVED THE EFFICACY OF HIS PRE-EMERGENCE HERBICIDES, WHICH HAS GIVEN HIM THE CONFIDENCE TO USE MORE EXPENSIVE CHEMISTRY.

I think using the liquids has helped with root disease and has definitely improved early crop health.

"In the past I've tried high rates of urea to push crops along and always been really disappointed with the results. When I tried sulphate of ammonia, all of a sudden I noticed a big jump forward. I should have known it would work, based on what a retired neighbour told me seven or eight years ago. He remembered spreading 200kg/ha of sulphate of ammonia before seeding, sowing the crop and shutting the gate. That's all he did for the whole year and he reckons they were the best crops he ever grew.

"If you look at a soil test, our sulphur levels are more than adequate, but if you apply sulphate of ammonia to a crop, the crop just goes."

The Berends apply a baseline rate of 150kg/ha across their cereal paddocks, with a higher rate on sandy soils, where they get a more visual response than on heavier soil types.

The cost is about $60/ha, which is easily covered by the increase in crop performance.

Two seasons ago Jason also started experimenting with spreading chicken manure on sandy soils; engaging a contractor to spread 3t/ha of chicken litter at a cost of about $130/ha. The results have been impressive.

"The result was a really healthy, good-yielding crop where we'd normally have a half-starved, yellowish crop. It wasn't scientifically analysed, but the area we treated with the manure would always be our worst-performing area with the least ground cover. In 2017, after spreading chicken litter, the crop was as good as any on the farm. It was a show-the-bank-manager type of crop.

"Spreading litter is fairly expensive but it might be something we only have to do every two or three years. We didn't do it last year but could still see some residual benefit from the previous year's application.

"Securing the material is going to be the biggest issue going forward. It's very hard to get because everyone wants it."

Weed wrangling, Mallee style

SARAH JOHNSON

A Mallee farming family is on a mission to reduce weed populations and avoid chemical resistance developing by using a range of weed management strategies including narrow row spacing, harvest-time seed destruction, hay cutting and targeted broad leaf spraying.

Wade Nickolls and his family have had weeds on their mind for years.

The Pinnaroo-based continuous croppers sold their sheep and cattle in 2008 and, in 2011, when SANTFA last interviewed them, were focussed on reducing the farm's weed seed bank, which their livestock had helped increase by spreading seeds across the property.

Almost eight years on, weeds remain a major consideration but Wade is in no doubt their weed management has 'come a long way' and is on the right track.

"We're still spending a lot of money on weed management but our paddocks are much cleaner than they were seven or eight years ago and unbelievably cleaner than 20 years ago."

Wade, who farms with his wife Danielle and brother Chad, with support from their father Jeff who is now retired, is quietly confident about the family's approach to weed management.

"I guess we're trying to get to the stage with weeds that we can choose when and what we sow in a paddock, rather than be totally governed by the weed situation," he said. "We're still a long way off getting it perfect but can now sow what crop we want across about half of our farm."

The Nickolls family crop 5,500ha of owned and leased land in Mallee country in SA and Victoria, sowing a rotation of wheat, barley, lentils, oaten and vetch hay, lupins and canola.

Problematic weeds include ryegrass and brome grass, with broad leaf weeds a challenge in their lentil crops, which have become a significant part of their rotation.

The Nickolls believe they are beginning to win the battle against ryegrass, although it remains a focus of their weed strategy, and they are increasingly concerned about brome grass. "Brome grass is starting to sneak up more and more and we're seeing it on our better country where we haven't noticed it before. We have to keep at it for that reason."

WADE, CHAD AND FATHER JEFF NICKOLLS DURING A BRIEF BREAK IN HARVEST.

Hay cutting, one of their effective ryegrass reduction strategies, is not as suitable for brome grass. "Hay is nowhere near as good an option with brome grass because it matures too early," said Wade. "Ryegrass matures at about the same time as oaten hay so you can cut it, kill it and get it out of the paddock with the hay, whereas brome grass quite often goes to seed before you can cut the hay. There are ways around it but you have to be careful with brome grass."

Hay cutting is just one of the non-chemical options the Nickolls have used for managing weed seeds at harvest time. The others are using a chaff cart, narrow windrow burning and, more recently, running Seed Terminators on their headers, which has eliminated any need for burning.

"People don't like fires these days and I don't particularly like burning anything if I can help it," said Wade. "The chaff cart was working really well but we were lighting a lot of fires to burn the chaff. With narrow windrow burning we were still lighting fires and some of those were getting out of control and burning entire paddocks instead of just the rows."

Three years ago the family bought two Seed Terminators as part of a pilot program, fitting them to their John Deere S670 and S680 headers. The Seed Terminator is an Australian-made harvest-time mechanical weed seed elimination system designed by Wade and Chad's cousin Nick Berry, who invited them to be involved in the testing and development phase of the machine, which is a market competitor to the original harvest-time weed seed control system known as the Harrington Seed Destructor.

"Last season was our third year doing harvest-time seed destruction," said Wade. "We're using two Seed Terminators, one on each header. There have been a lot of teething problems but the concept is very good and hopefully each year it will become more consistent and achieve better weed kill.

"Unlike the Harrington system, which is a hydraulic drive machine, the Seed

Terminator has a mechanical drive that runs off the gear box on the header, with a belt drive down to a 90-degree gear box behind the sieve. The weed seeds that come over the back of the sieve get pulverised and all the good material goes back onto the paddock, which is pretty important to us because that's contributing to soil cover."

Wear and tear on the machine's mechanisms is one of the main issues the Nickolls have encountered with their Seed Terminators.

"Our soils out here are very sandy and soil particles can wear down the components of the Seed Terminator quite badly. People use sand to blast paint off things and that's effectively what we're doing to our seed destruction mills.

"The first year was about keeping the machine running, including belts and gear boxes. The second year was more about the wear issue. Hopefully they've addressed both of those things now.

"They improved the drive situation in the first year and they're focussing on wear and machine longevity now, so it should become more consistent. They've recently changed coating materials and steels and included harder-wearing components, which will hopefully address the wear issues.

"SAGIT (SA Grain Industry Trust) has done trials to analyse weed seed kill rates and the results were very good. I think they were more than 95% effective.

"In one of our paddocks where we had a bit of ryegrass last year we used a Seed Terminator on the header at harvest then grew hay there this year with no pre-emergence chemicals and there were barely any weeds out there. That's basically a no-chemical year for that paddock.

WADE NICKOLLS HAS HAD SOME TEETHING PROBLEMS WITH HIS SEED TERMINATORS, BUT THEY ARE DOING THE JOB.

"I'm sure our weed situation is getting better. You just know that with every weed you kill and prevent from setting seed, you're in front."

Wade says each Seed Terminator represents an investment of about $100,000. "It's a lot of money, but if the maintenance is no more than $5,000 to $10,000 a year I think it's beneficial going forward because seed destruction doesn't require chemicals. It's absolutely, totally away from chemicals, which is a good thing."

Another consideration with the Seed Terminator, which is integrated into the harvester, is the extra fuel required and the impact on harvest time lines. Wade estimates they use 15 to 20% more fuel with the Terminators and concedes that they slow harvest.

"To be honest, if you work on the number of harvest days you would do a few more because running a Terminator means you use more fuel and it slows down your machine. On the other hand, it hasn't increased our total work load because it saves us having to burn all of those windrows and doing that work later. Overall we're in front."

Chemicals are still part of the Nickolls' weed management program, with the family using a range of pre-emergence chemicals including Boxer Gold, Treflan, Avadex and Sakura.

"We use the expensive pre-emergence chemicals that growers in higher rainfall areas use at robust rates despite the up-front cost," said Wade. "All of our paddocks are treated differently, depending on what we've got in each paddock."

He also uses glyphosate and has no doubt about the impact on the agricultural industry if it was to be withdrawn from the market; one of the ideas that emerged around recent media reports raising health concerns about the chemical.

"It would be horrible on a farm without it," he said. "We rely on glyphosate a lot. I would say there would be a lot of farmers who would say it's too hard to farm without it. I think farmers are being as careful as they can with it and using it within reason. Australia is one of the most regulated countries in the world in terms of chemical use.

"Our approach is that with harvest seed management we can keep using glyphyosate for a long time in our system. It's about having it as part of an integrated weed management strategy."

WEEDit precision spraying technology, which uses linked near infrared (NIR) sensors to detect green plants, also has a role in the Nickolls' integrated weed management strategy.

Their 36m-wide stand-alone WEEDit unit, which they bought four years ago after trialling a friend's system for two years, carries 6,000L and 1,200L tanks and is towed behind a John Deere 8320R tractor. It is used mainly to target broad leafed weeds over summer, but they have been able to used it at seeding twice in the past six years, which Wade considers 'a bit of a win'.

The WEEDit technology, which makes possible what is effectively spot-spraying using a boom spray, enables them to avoid the cost of applying multiple blanket sprays over summer and autumn.

"Now we blanket spray a paddock once then go across it three or four times with WEEDit, which targets individual weeds. With WEEDit we can apply twice the blanket spray rate of chemical on each plant, which improves our results on hard-to-kill broad leaf weeds like marshmallows and turnips, while using only 10% of the amount of chemical applied in a blanket spray. That saves us money and we do a better job because we're putting more chemical on each weed.

HARVEST-TIME SEED DESTRUCTION IS AN IMPORTANT ELEMENT OF THE NICKOLLS' INTEGRATED WEED MANAGEMENT PROGRAM.

"We've also used WEEDit at seeding time because there's not much growing on the paddock then. The unit has two tanks and two lines, so we can use one line to target green broad leaf weeds with glyphosate and use the other tank and line to apply a blanket spray of pre-emergence chemicals at the same time.

"The cost of a large WEEDit unit is probably about $350,000, or perhaps even more now, but we think it will pay for itself in five years.

"If there are concerns about the amount of herbicide used in farming the WEEDit technology is a positive because it enables us to spray only a bit of chemical directly onto the weeds. If anything, the government should give incentives for growers to buy them because for a small farm, $350,000 is a large outlay."

Attracted by improved varieties and refined seeding technology, the Nickolls are back growing lentils again after a break of several years.

"We grew lentils, which now comprise about a third of our cropping program, in 1998 to 2000 but the varieties and our seeding systems weren't that good," Wade said. "The varieties weren't consistent enough and we probably didn't use all our moisture.

"Now our seeding system is considerably better and the breeders need a pat on the back because current varieties are much better suited to our environment. They grow higher and can grow more grain on less rainfall. They've also got better disease resistance.

"Lentils fit our conditions well because they need stress at the end of the year to make them flower properly and we usually get that. They're not right for everyone around here but we can grow a lot of them on our soil type."

Their lentil seeder is a Horwood Bagshaw tined machine they have progressively adapted to suit their property and rotation. It is set up with a Stiletto split system that sows two single rows about 70 mm apart.

"It's like a paired row," said Wade. "The seed isn't placed directly on the row but

RUNNING TWO HEADERS INCREASED THE NICKOLLS' HARVEST EFFICIENCY BUT THAT GAIN HAS BEEN REDUCED BY THE SEED TERMINATORS, WHICH HAVE INCREASED FUEL CONSUMPTION AND EXTENDED THE TIME IT TAKES TO GET THE GRAIN OFF; THOUGH NOT THE OVERALL HARVEST WORK LOAD.

about 35mm either side of the line of the tine, with an inter-row space of 300mm between the pairs of rows. We've done it for three or four years now as a way of increasing weed competition."

They are also exploring the potential of a John Deere single disc opener which they used to sow a 30ha paddock last season but the early results have left Wade unconvinced about the effectiveness of disc seeding in the Mallee.

"We played around with it last year and I'd like to see it work but at the moment it's not looking too favourable. I adjusted my pre-emergence chemical rates quite a lot due to the lack of soil throw from the disc but we still got a lot of chemical damage. The crop was very slow out of the ground and the vigour was very poor. Even the plant numbers weren't good.

"The crop was sown in good conditions, just a day after the tine-seeded crops, and the disc-sown crop looked very average all year. It just never looked strong compared to our tine-planted crops, although it was catching up and looking okay towards the end of the season.

"We may be able to make a disc seeder work but it's a matter of how long we need to persevere to achieve that."

The Nickolls' interest in disc seeding is driven by a desire to maintain as much stubble cover as possible and make use of all the available rainfall, which on average is 330mm annually. "Every 5mm of rainfall you can make use of is of benefit to you, so it's important to have that extra mulch on the ground," Wade said. "Unfortunately, I haven't seen anyone in this area or rainfall zone make disc machines work that successfully."

Soils across the Nickolls' property range from heavier loams to sandy loams, with 10% non-wetting sands. The family has invested in several strategies to correct non-wetting in their sands and sandy loams, including delving and spading. Seven years ago they delved problem areas; pulling clay from depth and mixing it through the soil. "We delved any area where we could get deep enough to pull the clay up, and if we couldn't do that we dug clay from a pit and spread and incorporated it across the hills," said Wade.

"Hopefully that was a one-off. It's made the soil much better to deal with and helped us produce more consistent yields. Where we have been able to increase the clay content in what was non-wetting soil the crop is much healthier and germinates with the weeds, which helps keep them under control."

FARMERS IN TRAINING – WADE'S SON JACK [CENTRE] WITH CHAD'S SONS HARLEY [LEFT] AND BROCK [RIGHT].

They are now beginning to use a deep ripper, which a local engineer has built for them and two other local growers, to tackle soil compaction. "Three of us wanted one so we thought we'd get one built and see if we like it. If we do the engineer will build a couple more so we've all got one."

Deep ripping, to a depth of 300 to 500mm, is intended to break up the compaction layer in the Nickolls' sandy loams and Wade is hoping a combination of deep ripping and spading will improve water use efficiency in paddocks where there is a compaction layer.

"Spading mixes the soil down to 700mm. It's like a massive rotary hoe that spades fertiliser and nutrients like zinc, copper and gypsum through the soil to get them moving through the profile and open up the root zone. At the moment we have areas with a hard pan that stops the roots moving down through the profile. They just go sideways and eventually run out of moisture.

"The spading is a one-off but we'll probably deep rip every few years on some of those soil types. I think it will be important to be on a controlled traffic system so we don't drive over ripped soils too much afterwards."

The family are systematically moving closer to a controlled traffic system, with each new machine on a three-metre wheel base, although they have dual tyres on their headers, which means it's not a perfect set-up. Their header fronts are 12 metres wide, they have an 18m seeder and their sprayer and spreader are each 36 metres wide. "Controlled traffic is a good idea but there's a lot you have to get right first."

Wade and his family lease almost a third of their cropping land and implement a range of fundamental strategies in each new paddock they take on, with a particular focus on weed management. They look for longer leases, usually between three and five years, to ensure they can reap the benefits of these strategies. "Ten years ago, when we leased a farm, we put in as much wheat and barley as we could. Now we treat it like our own and grow a lot more break crops, like canola, lentils and hay, to get the weeds down. After one or two years it might not be quite as good as your own land but it's a lot easier to manage.

"We're trying to build relationships with the land owners too. Basically their farms are getting cleaned up for them and they're getting paid for someone to do it."

The Nickolls have expanded their cropping operation from 4,000ha to 5,500ha in the past eight years and plan to crop 5,800ha next season. Wade says the family isn't 'busting to expand', but feels it's probably the right time. "I'm 40 and Chad's 37, so it's not like we're at the end of our farming lives. We feel like we're at the time of our lives where we can handle expansion. So I guess the plan is to expand, as long as it's in the right country and at the right price."

Nitrogen – know the system, do the numbers

GRAEME JENNINGS

Could less intensive cropping programs improve growers' financial and environmental sustainability? Aspects of a CSIRO paper that draws together the multiple scientific and economic strands of decades of nitrogen-related research would seem to suggest the question is at least worth asking.

Aiming to optimise, rather than maximise, yields could open the way to environmental and economic sustainability for growers cropping soils with falling organic matter and nitrogen (N) levels and facing rising fertiliser N costs.

This is one of the messages from a GRDC-funded CSIRO study of nitrogen dynamics and their impact on productivity and profitability.

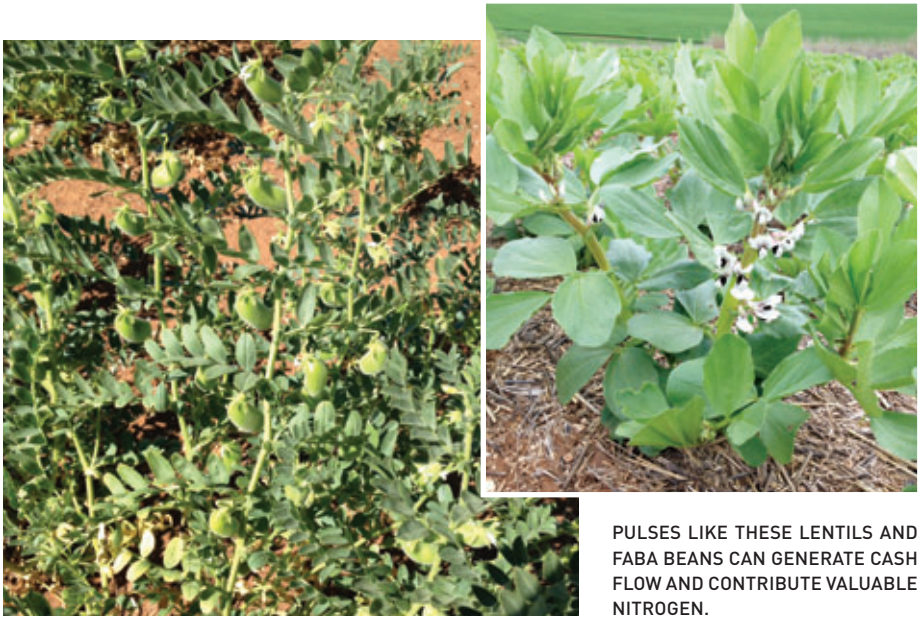
This comprehensive paper, which draws together the results of decades of Australian N-related research, says soil organic matter content of Australian cropping soils has fallen to 30-80% of comparable soils under native vegetation, with a consequent reduction in soil N reserves. Because N and carbon (C) are bound together in organic matter, lower levels of soil organic matter mean there is less N available to be mineralised into a form available to plants.

The team that undertook the study, prompted by the fact that N levels in Australian soils are declining under modern cereal-oilseed cropping rotations, was headed by CSIRO research scientist Dr Jeff Baldock.

The decline in soil N identified in the paper is an average position, with actual levels determined by factors including environmental conditions, soil characteristics and properties and management practices. This variability means growers need to track the effects of their farming practices on long-term soil productivity and N supply capacity by calculating the impact of their cropping program on soil N reserves each year, the authors say.

N measurement, and management, is complicated by the fact that N is 'tied up' in and released from the soil by the action of soil organisms.

The involvement of microorganisms in this biological process takes on extra importance given the weight placed by the authors on matching N supply to crop demand for the nutrient. Matching the supply of N to crop demand is critical to optimising nutrient use and profitability of grain production, they say, with soil N having a key role in achieving that.



PULSES LIKE THESE LENTILS AND FABA BEANS CAN GENERATE CASH FLOW AND CONTRIBUTE VALUABLE NITROGEN.

Since grain crops access N from the soil and any applied fertiliser N, maximising profits requires knowledge of the amount of N that can be supplied by the soil to ensure that optimum fertiliser application rates can be defined.

Soil-derived N is a limited resource that can make a significant contribution to the amount of N available to a crop, the authors say, and growers need to identify how much available N a soil can provide for a crop prior to and within the growing season to help optimise N fertiliser application rates.

As the capacity of a soil to deliver available N to crops declines, growers become more reliant on fertiliser N, with the potential for lower fertiliser N use efficiency and N loss increasing as fertiliser N rates increase.

Fertiliser N is more likely to be lost through volatilisation, leaching or denitrification than N released from soil reserves and this, combined with the cost of buying and applying fertiliser N, could make growing less, whether by targeting lower yields or changing to less intensive rotations, more profitable and sustainable in the longer term (>10 years) than targeting maximum yields every year.

Targets

Setting and achieving appropriate yield targets is key to profitable grain production, with provision of an appropriate supply of N and other nutrients as they are needed by the crop over the growing season required to optimise profitability, the authors say.

Yield of rain-fed grain crops is usually limited by moisture availability but can also be impacted by lack of N during the growing season, in which case the potential maximum water limited yields will not be achieved. Ironically, having too much N available early in the growing season can result in excessively vigorous vegetative growth that can exhaust soil moisture reserves and lead to crops 'haying-off' due to lack of moisture later in the growing season.

Crop N requirements are estimated using potential grain yield based on water availability (stored soil water at sowing plus growing-season rainfall) plus protein targets. To define an appropriate fertiliser rate that matches N supply with crop demand a grower has to know how much

N will be delivered from the soil. Lower soil N levels mean more fertiliser N will be needed to achieve water-limited yield potential – maximise grain yields, in practical terms – with the required rate of N fertiliser reducing as the N contribution from the soil increases. In simple terms, cereal and oilseed crops are more reliant on fertiliser N in soils with lower N supply capacities.

In many instances the economic optimum – the yield at which profit will be maximised – will be achieved with an N fertiliser rate less than that required to maximise yield, the authors say.

Applying too little fertiliser N will reduce profit due to the opportunity cost associated with forgone grain yield, while the cost of buying and applying excess fertiliser will reduce profit if too much fertiliser is used. The ideal is an application rate between those extremes that will optimise grower profit. This rate will almost always be different from one that will maximise yield.

The biological processes that release soil N from organic matter in the soil are controlled by the same environmental stimuli – temperatures and moisture – that drive plant growth, so N release from the soil during the growing season is generally in sync with a crop's need for the nutrient. This means N from organic matter decomposition is effectively 'metered out' over the growing season, leading to lower accumulations of available N in the soil, which reduces the risk of N loss from the system.

Achieving this synchronisation across a cropping program requires an understanding of crop demand over the growing season and how best to satisfy that demand; with estimation of how much and when N from the soil will be available being the starting point for deciding how much fertiliser N to apply.

Given that buying and applying fertilisers is 20-25% of the variable cost of dryland cereal and oilseed production in Australia – compared to 6-16% for pulses, which obtain a significant part of their N needs through rhizobial fixation of atmospheric N – being able to accurately predict and maintain the provision of N from soil will lead to more profitable grain production.

Failure to understand the amount of N available from the soil at different times throughout the growing season and changes in moisture availability across the season can lead to application of inappropriate rates of fertiliser N, resulting in sub-optimal yields and reduced profitability.

THERE IS NO DOUBT WHEAT CAN BE A PROFITABLE CROP, BUT THE COST OF AND POTENTIAL LOSSES FROM NITROGEN FERTILISER MEAN GROWING LESS BY TARGETING LOWER YIELDS OR WIDENING ROTATIONS COULD BE MORE PROFITABLE AND SUSTAINABLE THAN TARGETING MAXIMUM YIELDS EVERY YEAR.

N cycle

More than 95% of soil N is contained in insoluble organic matter including plant residues and soil microorganisms. However, plants can access N only when it is present in a soluble form: soluble organic nitrogen or ammonium and nitrate forms of inorganic N produced during decomposition and mineralisation processes that are controlled by moisture and soil temperature.

The microbes involved in decomposition of soil organic matter and mineralisation of insoluble organic N into plant-available forms also need N themselves and if the organic matter being broken down does not contain sufficient N to satisfy their requirements they will scavenge available N from the soil, which can lead to it becoming temporarily unavailable to the crop.

Such immobilisation typically occurs when crop residues with high C:N ratios, such as cereal stubbles, decompose in soil with little soil N.

Immobilised N is not lost from the soil system but is 'locked up' in the microbial population and can be mineralised back into a plant-available form later in the season or in following years.

Options

Growers can add N to their soils in one of three forms – as soluble inorganic N in fertilisers such as urea, di-ammonium phosphate (DAP) or mono-ammonium phosphate (MAP), organic N in additives such as manure and compost or biological N from growing grain or pasture legumes that support N-fixing rhizobial bacteria.

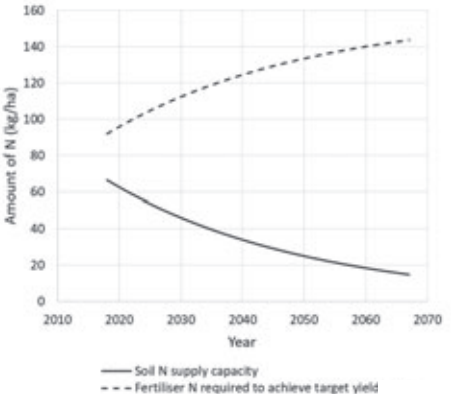
On the other side of the equation, N is removed from paddocks in harvested grain, hay or meat and can be lost through leaching of available N in large rainfall events, volatilisation of ammonia due to high soil pH or poor conditions after surface application of granular urea or denitrification of nitrate in soil that remains wet for prolonged periods.

The potential for N loss increases with the amount of available N in a soil , so matching the supply of available N to crop demand will reduce accumulation of available N and the potential for N loss

Management

Fertiliser N application rates are generally based on results of rate trials that have tended to identify the minimum amount of fertiliser N required to optimise annual profitability. However, soil N data suggest that this approach has resulted in grain growers effectively mining N from the soil.

While this can enhance annual profit,



CHANGE IN SOIL NITROGEN SUPPLY CAPACITY (SOLID LINE) AND FERTILISER NITROGEN REQUIREMENT (DASHED LINE) REQUIRED FOR 3T/HA WHEAT GRAIN YIELD WITH 11% PROTEIN.

decline of soil organic matter reserves and associated N levels diminish the ability of soil to supply the N required to meet crop demand. This increases the difference between the amount of N required by grain crops and the quantity that can be supplied; a gap growers aim to fill with fertiliser N.

A short period of negative N balance is acceptable provided it is followed by a rebuilding phase of regenerative practices such as stubble retention, grain and pasture legume production, green manuring, application of organic amendments and use of appropriate quantities of fertiliser N to enhance crop growth and increase the stock of soil organic N.

If soil N stocks are not replenished the gap between need and supply will increase, leading to an increasing dependence on fertilisers to achieve desired grain yield outcomes, the authors say. And since the efficiency of fertiliser N decreases with increasing rate due to the risk of available fertiliser N being lost through volatilisation, denitrification or leaching; having to increase fertiliser N application rates to compensate for a decreased ability of the soil to supply N is likely to reduce profitability.

In short, assuming other variable costs remain fixed, the economic optimum yield and profitability will decline as the ability of a soil to supply N decreases.

Measure

One of the challenges for growers wanting to tackle soil N issues is how to measure what is happening in their soils and their balance sheets, and when to measure soil N levels.

The amount of N mineralisation that occurs between crops has typically been assessed by analysing soil cores prior to sowing, with levels of more than 200kg N/ha having been measured in pre-sowing cores. Summer soil N stocks are generally higher after canola, grain legumes and pastures than after cereals.

For the most useful measure of N availability sampling depth should be the effective rooting depth of the crop to be sown.

Plant and soil test data can be used in a variety of economic measures or indicators, each with its own 'best fit' applications. The researchers suggest growers, or their consultants, use two of these measures – partial nutrient balance (PNB) and nutrient balance intensity (NBI) – at farm or paddock scale to calculate their annual N balances each year.

Each paddock has different annual inputs, extractions and losses of N due to different management practices, soil properties and environmental conditions so it is important for growers to calculate nett N balances to track the impact of management practices on soil N stocks, the authors say.

A negative N balance, indicating the soil N resource is being mined, might indicate that long-term productivity and potential profit is being eroded to maximise short-term returns.

The results of these calculations should be integrated and accumulated year-on-year to account for crop rotations and variations in environmental conditions and yield. This will identify the full effect of applied management practices and trends over time and provide a reference for appropriate action to maintain the resource base and maximise profitable grain yield outcomes into the future.

Robert Norton, Regional Director of the International Plant Nutrition Institute, who used four or five years of data to calculate PNB and NBI across 514 paddocks on 125 farms in south-eastern Australia, found an average nett removal of N across those properties. It is considered likely the actual N losses are greater than Norton's 2016 figures indicate because he did not take account of losses due to leaching, ammonia volatilisation, denitrification or erosion.

NITROGEN BASICS

Measuring and managing nitrogen (N) availability is challenging because of the strong interactions between the factors influencing the ability of a soil to mineralise organic N and make it available to crops.

However, a GRDC-funded CSIRO study of nitrogen dynamics provides a summary account of some basic facts about N biology that informs decision making about soil N management.

- **The production and retention of available N increases, peaks and then declines with increasing soil water content, while mineralisation and the production of available N increase with increasing temperature. This suggests a measure such as 'microbially active degree days' may provide a better indication of environmental impacts on the delivery of available N from soil than some of the other metrics available, according to the authors of the report.**
- **The content and composition of organic matter as well as soil texture, soil depth and soil biology can all alter the amount of N mineralised, with the characteristics of the organic matter also likely to influence the rate at which soil N is made available to crops.**
- **Agricultural management practices influence nutrient mineralisation principally through their impact on the quantity, composition and handling of crop and pasture residues. The quantities of residue returned to or onto the soil vary substantially depending on crop species, soil type and environmental conditions, with the species having a strong impact on the composition of the residues.**
- **Initial nett immobilisation of N is likely where large inputs of cereal residues with low nutrient content are returned to the soil. However this is not permanent, with the immobilised nutrient becoming available later as decomposition resumes. Mineralisation of N is likely to be greater where legume residues are returned but the amount of N returned in grain legume residue declines as the harvest index of the grain legume increases.**

Diversity a conference characteristic

GRAEME JENNINGS

Bench marking, rotations and soil biology, large-scale high-tech production, business management and mental health will all have an airing at this year's SANTFA conference.

The banner for the conference, the association's 21st annual showcase event, is 'profitable farming and healthy soils', subject areas that will be addressed specifically by renowned US speaker Dwayne Beck, returning after a break of 13 years, Simon Vogt, who will report on the results of a profit-focused benchmarking exercise and David Ricardo, a NSW grower who is using a high-tech 'corporate farming' approach in his diverse cropping program.

Darren Thomas, Chief Executive Officer of SA-based Thomas Foods, will provide a different but closely related business perspective, drawing on his family's experiences in growing their multi-million-dollar global business to illustrate concepts growers can apply to their farm enterprises. He will also present an outlook for livestock production, which will be of value for growers thinking of running cattle or sheep with their cropping programs, and reflect on how the company is managing recovery from the fire that destroyed its meat processing plant at Murray Bridge.

Other speakers will include SANTFA R&D director Greg Butler, who will report on the latest developments in SANTFA's research initiatives, Jarred Tilley, a Mid North farmer who will explore the profit drivers in farm businesses and the benefits of business benchmarking, and Michael Hancock, a West Coast producer involved in tackling health issues.

This year's conference will be on Friday, March 1, at the Barossa Arts and Convention Centre, in Tanunda.

Dwayne Beck, who presented at the 2000 and 2006 SANTFA conferences, will draw on observations from more than 35 years of work in broadacre cropping to provide an overview of the current state of play in global cropping systems with an accent on the importance of understanding and replicating natural eco systems to capitalise on nature's cycles and systems to maximise productivity and soil health.

IT'S ALL IN THE SOIL. DWAYNE BECK BELIEVES MANY OF THE IMPROVEMENTS IN FARMING OVER THE PAST 30 YEARS CAN BE TRACED BACK TO IMPROVED UNDERSTANDING OF THE BENEFITS OF HEALTHY, BIOLOGICALLY ACTIVE SOIL.

According to Dr Beck, Research Manager at Dakota Lakes Research Farm, many of the improvements in farming systems over the past 30 years can be attributed to improved understanding of natural systems, the benefits of developing a healthy, biologically active soil ecology and what happens when cultural practices such as rotation and competition are the primary methods of pest control.

In diverse, robust cropping systems with healthy soils the focus is on preventing or avoiding a problem rather than correcting it and natural cycles and principles become allies, with inputs such as fertilisers used only to augment or initiate natural cycles to advantage the crops being grown, he says.

David Ricardo and his brother Peter run Morenvale, a 9,000ha no-till cropping enterprise between Walgett and Collarenebri on the north-western plains of NSW, where they grow wheat, barley, chickpeas, faba beans, cotton and canola.

They have no livestock, use a controlled traffic system to minimise compaction of their heavy flood-plain soils and place a high priority on stubble retention and retaining cover on the soil surface to store moisture and 'keep it as near the surface as possible'. They are also exploring the potential and impact of cover cropping in their environment.

David will focus on their approach to the business of agriculture and explain what led to development of their current farming system, how they manage their diverse rotation, where they are 'at' with cover cropping and the pros and cons of their controlled traffic system.

Rural Directions Agribusiness Consultant Simon Vogt will highlight the importance of management, planning and simplicity in his presentation of the findings from a three-year benchmarking study of SA farm businesses that was finalised last year.

The study identified gross margin, low overheads and good management of people and risk as the biggest profit drivers for SA producers, with timeliness of sowing a critical factor for cropping enterprises.

Simon will tell the conference there is a place for livestock in farm businesses, particularly in the Mallee and on upper Yorke Peninsula, where medic or vetch pastures have higher gross margins than low-yielding canola or bean crops, provided they are profitable and do not over-complicate farm management.

He will also point out that average producers can move their enterprises into the top 20% of profit makers by improving management, without needing to increase the size of their holdings.

Blending for a bottom line boost

SARAH JOHNSON

After three seasons using a header-mounted grain analyser and blending grain in the paddock to optimise wheat grades, the Jericho family are convinced the practice is adding thousands of dollars to their wheat and barley profits.

Despite early reservations about real-time analysis of grain protein levels, Kimba-based mixed enterprise farmer Shane Jericho and his family are now committed to in-field grain blending as a way of optimising grain prices.

"There's money to be made in blending grain in the paddock to try and get the best return," said Shane. "You invest so much time and effort in growing the best possible crop you can and to me, measuring your protein and blending in the paddock is the last piece of the cropping puzzle. We are consistently achieving a $20,000 return over a season from upgrading our wheat by blending."

"And this year we've been able to blend barley to meet malt specifications. We've achieved premium grade barley, which is worth $50/t more than feed barley this season. That equates to an extra $3,000 for every road train."

Shane, a fourth generation Eyre Peninsula grower, farms with his wife Sharna, older brother Damien and parents Rob and Lyn. Based 15km south-west of Kimba, they crop 3,200 hectares of wheat and barley on a 5,200 property that includes 2,000ha of leased land. They also run a 1,000-ewe self-replacing Merino flock.

It was the fortuitous purchase of a second-hand Case IH 8230 header in 2016 that steered the Jericho family towards in-field grain blending. Only a few months earlier they had decided against buying an on-board grain analyser, but the header came fitted with Next Instrument's CropScan 3000H On Combine Analyser.

"We originally chose not to invest in an analyser, then 12 months later had one by default," said Shane. "At the time we didn't think we had a need for it because we didn't grow enough high protein wheat, but the results from the analyser in that first year showed how much variation there is in protein levels across our paddocks. This season the protein has ranged from 8% to 14.5%."

The CropScan 3000H grain analyser is a real-time device that measures protein levels of grain in the header every eight to 12 seconds, creating a screen-based protein map and providing average protein and moisture levels. It can also measure oil content when harvesting oilseeds.

SHANE JERICHO, AT THE CONTROLS OF THE FAMILY'S HEADER, ADJUSTS THE SCREEN OF THE GRAIN ANALYSER, WHICH RECORDS THE AVERAGE PROTEIN LEVEL OF EACH HEADER BIN OF GRAIN. THE HEADER DRIVER IS RESPONSIBLE FOR COMMUNICATING THAT PROTEIN LEVEL, WHICH DETERMINES WHICH FIELD BIN THE GRAIN IS TO GO INTO, TO THE CHASER BIN DRIVER.

For Shane and his family the system has shifted the harvest focus from yield to protein.

"Watching the protein adds a whole new dimension to harvest," said Shane. "Because you're watching it live all the time it's pretty rewarding and satisfying when you get the blends right, especially when you can upgrade grain so you get more money for it for not much effort.

"When we go to start a new paddock now, the first question we ask one another is, 'what's the protein going to be?' There used to be a lot of anticipation about yield, but now our focus is on protein more than anything. It's been a real shift.

"You can't do anything about the yield by the time you get to harvest. At that point it's out of your control. It is what it is."

However, being able to blend grain of different protein levels means things are different with protein.

The price of wheat delivered to a silo is determined by its grade, with the price difference from one grade to the next generally $10 to $15/t. Grain with less than 10.5% protein is classified as Australian Standard White (ASW). Australian Premium White (APW) has protein between 10.5 and 11.5%, Hard 2 (H2) grain is between 11.5 and 13% protein and Hard 1 (H1) has grain protein of more than 13%.

The grain is analysed at the point of delivery and graded on the basis of the average protein level of the load, which determines the price paid to the grower for that grain.

Using a grain analyser on the header means the grower knows the grade he is likely to get before the grain is trucked out to the silo and, more importantly, has the opportunity to blend grain in the paddock to achieve the highest possible grade.

The Jericho family uses eight field bins for grain blending during harvest. The analyser records the average protein level of each eight-tonne header load and keeps track of protein levels in each field bin. The average protein level of each header load determines which bin that grain goes into.

TRUCKS CARRYING WHEAT TO THE SILO ARE LOADED FROM DIFFERENT FIELD BINS ACCORDING TO DECISIONS BASED ON THE PROTEIN LEVEL IN EACH BIN AND WHICH MARKET GRADE SHANE AND DAMIEN ARE AIMING TO ACHIEVE.

When it is time to load the carrier's road train with grain for delivery to the silo they use the average protein level of the grain in each bin, which the analyser has tracked, to decide which grain to load into the truck.

They don't always blend grain to improve the grade, particularly if the protein level in a bin sits in the middle of a grade range. If this is the case they will commit to that grade classification and load the truck with grain from two field bins with the same protein level. However, if the protein level in a field bin is close to the threshold of a higher grade they will choose a second bin with higher-protein grain to lift the average protein of the truck load to a level required for the higher grade.

"You don't want to deliver grain that is at the top end of the threshold but not meeting the next grade," explained Shane. "If we've got grain in a bin that's 10.2% protein that means it's nearly APW grade

Wheat16H	Protein	Moisture	Location	Weight
Field Ave	12.7	10.9		
Bin Ave				
ast Reading				
Bin13				
Bin12	11.4	10.7	VENNINGS	1
Bin11	12.9	10.7	VENNINGS	8
Bin10	12.1	10.6	VENNINGS	8
Bin9	13.2	10.8	VENNINGS	4
Bin8	13.7	10.8	VENNINGS	8
Bin7	13.5	10.9	VENNINGS	8
Bin6	13.6	10.9	VENNINGS	8
Bin5	12.8	10.9	VENNINGS	8
Bin4	11.6	11.1	VENNINGS	8
Bin3	11.8	11.0	VENNINGS	8
Bin2	12.9	10.8	VENNINGS	4
Bin1	12.5	11.1	VENNINGS	8

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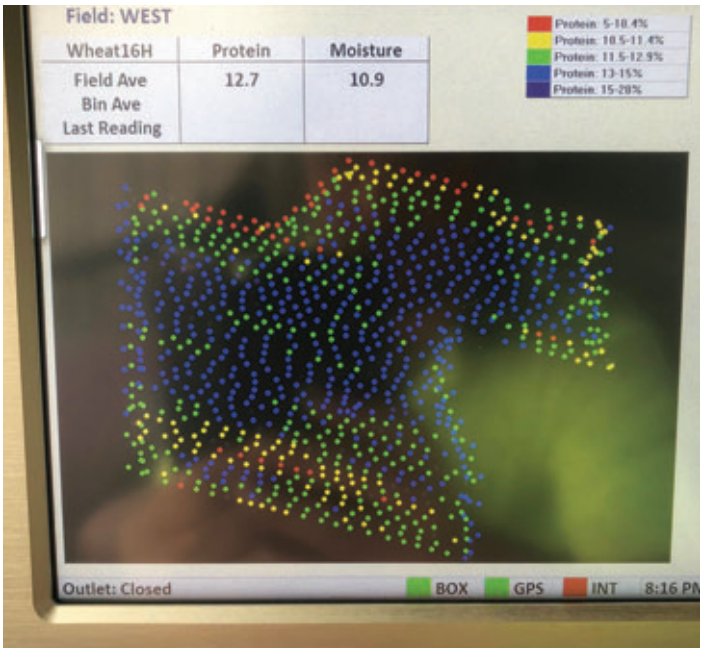


THE GRAIN ANALYSER'S ON-SCREEN DISPLAY OF THE PROTEIN AND MOISTURE LEVELS OF EACH HEADER BIN OF GRAIN [LEFT] IS USED TO MAKE DECISIONS ABOUT WHICH GRAIN IS TO GO WHERE AND WHAT GRAIN TO LOAD INTO WHICH TRUCK. THE ANALYSER ALSO GENERATES A PROPERTY PROTEIN MAP [RIGHT] SHOWING WHERE GRAIN OF DIFFERENT PROTEIN LEVELS WAS HARVESTED FROM; DATA THAT CAN BE USED IN DECISIONS ABOUT FUTURE PADDOCK MANAGEMENT AND NUTRIENT REQUIREMENTS.

but not quite there. If we go to the next paddock and the protein is at 11% we can blend the two to upgrade the grain from the first paddock to meet the APW classification. That's what we're trying to do.

"When we take the load to the silo we pretty much know what the protein level should be. Sometimes it's a little bit out, but we get it right nearly all the time."

The family checks the final result at the silo by logging into Viterra Australia's Ezigrain system via a smartphone.

Blending decisions in the paddock are made by the drivers on the header and chaser bin, with the header driver relaying the protein level information to the bin driver.

"You're reaping a box full every 15 minutes and it's something you've got to think about all the time. Whoever is on the header will tell the chaser bin driver what the protein is," said Shane. "We're learning on the go, but now that we've done our third season we're starting to understand it a lot more and know what we're doing."

They usually aim to increase the classification by one grade, but achieved a two-grade increase with one load during the 2017 harvest, when they found one paddock was averaging 8.9% protein but there was 13% grain in another paddock nearby. They decided to accept H2 grade for the 13% protein grain, rather than trying to find higher-protein grain to push it up to H1, but to mix it with the 8.9% grain. The blend was still H2, so the decision to mix the two batches had the effect of lifting the 8.9% protein grain two grades, from ASW to H2.

BROTHERS DAMIEN AND SHANE JERICHO IN HARVEST MODE.

The system has shifted the harvest focus from yield to protein.

"The higher-protein grain was really close to H1, but if we took it to the silo and it went 12.9% we would have missed out on H1 anyway. We did deliver some H1 grain out of those paddocks but we thought it was better to bring the ASW up two grades rather than risk not getting H1 for all the higher-protein grain.

"This year Viterra introduced Dynamic Binning, which has made our job easier. It means that if grain is only point one or two of a per cent below a higher grade they will upgrade the load, providing the stack average is high enough."

The Jerichos have four 70t silos they can use to blend grain but have found they are storing less of their grain since they began using the grain analyser than they were previously.

"We don't often use the on-farm silos because there's extra handling involved,"

said Shane. "We've got the confidence now to blend in the paddock and just send the grain out the gate in a truck."

The practice of blending grain to achieve a better financial outcome does not trouble the Jericho family from an ethical point of view, and seems largely accepted by the industry.

"We've never had any feedback from Viterra about the protein machine and what we're doing," said Shane. "They would be aware that people have them and Viterra are doing the same thing we're doing, just on a much larger scale. They're trying to blend it to get the best possible result, which is what we're doing. I don't think it would be frowned upon.

"In the future, more and more people will be getting protein machines because of the benefits; especially farmers operating on a larger scale. There are a lot of growers in this district who crop a lot more than we do and probably the bigger you get as a cropper, the more there is to gain from blending."

Six other growers in the Kimba area also operate a Next Instrument Grain Analyser. In the past they have shared their experience of using the system through a Closed Facebook Group and at a meeting organised by Next Instrument's founder Mat Clancy about 18 months ago. Shane says there hasn't been much recent activity in the Facebook Group. "It's a place where we can ask each other questions but people aren't really using it, probably because everyone is going along okay with the system."

At this point in their grain blending experience the Jerichos value harvest efficiency above blending results. "We don't let it interfere with our harvest efficiency," said Shane. "We still want to get the grain off as quickly as possible." This means they systematically reap full rows, rather than targeting protein levels within the paddock. "Because the analyser creates a map of the protein levels as you're reaping you might be able to see a trend and pinpoint where the high and low protein levels are in a paddock but we're not prepared to go half way up the paddock then turn around to try and reap the paddock for protein. We go from one end to the other and get our eight-tonne load at whatever the average protein is.

"Right now, our focus is on reaping the paddock as quickly as possible. After a few more years when we have multiple protein maps of the same paddocks we might know where the better protein is, but we're still relatively new to having protein maps and using this machine."

THE TEMPORARY STORAGE PROVIDED BY THE JERICHOS' EIGHT FIELD BINS ENABLES THEM TO BLEND THEIR GRAIN TO ACHIEVE PROTEIN LEVELS THAT MATCH WHEAT INDUSTRY GRADES.

They may also use of the protein maps to help make decisions about nutrient applications. "We will probably start using fertiliser at different rates across the paddocks and will be able to use grain protein information to work out how much nitrogen we need to put back in different areas to maintain future crops."

They generally find lower protein levels in wheat-on-wheat crops, and are working on improving their rotation and crop sequences. "Our agronomist has really steered us in the right direction with our crops and pastures, as well as our use of nitrogen and urea in the crops," said Shane. "He's really got us on the right path and I think we're seeing the results now of what we started with him five years ago."

They crop wheat, barley and lupins for harvest and grow vetch and medic pastures for their livestock and rarely grow wheat-on-wheat now, with wheat crops generally separated by a legume, whether pasture or lupins.

The very different performance of two neighbouring 2017 wheat crops, one after vetch and the other following wheat, provided Shane with a reminder of the impact of legumes on following grain crops. The wheat-on-wheat crop yielded 2.1t/ha, with grain protein of 10.5%. The crop following the vetch pasture yielded 3.4t/ha at 13% protein.

"We're trying to improve our pastures because they set a lot of nitrogen for the following crop," he said. "By improving our pastures we're going to naturally grow higher protein wheat and we are seeing our pasture improve. We used to grow a lot of ASW wheat but now we're growing more APW and Hard."

The Jerichos' grain analyser was part of their header purchase but similar units have a list price of around $20,000 plus GST; a figure Shane believes should be covered by using it for grain blending. "I think the grain analyser would comfortably pay for itself every year."

The family has found that the analyser requires very little upkeep, apart from a daily clean during harvest. "Each morning we make sure it's clean of any build-up of dust and then you can do a full day of harvesting without stopping for it," said Shane.

From a technical perspective, software updates are required annually, which can be done remotely by Next Instruments. "This year Mat Clancy updated the software from Sydney at the start of harvest. All we had to do was hotspot the grain analyser from my phone and Mat used Team Viewer to do the software updates remotely."

Covers, litter and the terms of trade

KATHERINE MAITLAND

After years of practicing no-till, retaining crop residues and applying chicken litter, Nuffield scholar Grant Pontifex has concluded growers need to grow more diverse, high-carbon cover crops to feed soil biology.

Paskeville farmer Grant Pontifex is dedicated to improving soil health and maximising the benefits of cover cropping on his family's properties on Kangaroo Island and Yorke Peninsula.

Those benefits include potential to maintain profitability in the face of rising costs and worsening terms of trade.

Grant, who has been spreading chicken manure from Port Wakefield poultry farms on his land for the past 12 years, is exploring the potential and practicalities of cover cropping and last year undertook a Nuffield scholarship to investigate the use of chicken litter, cover cropping and related to enhance soil health and crop performance.

"Currently, most agricultural soils do not have the capacity to sustain continuous cropping and high yield production without expensive synthetic inputs," he said. "Agricultural practices have become simplified to large-scale mono-cropping with very little diversity in rotations.

"I have been planting cover crops on our Paskeville property for many years but wanted to take a more biological approach to farming coupled with scientific facts and replicated trials, and decided to use my scholarship to focus on how to boost soil health and improve biology, water holding capacity and water use efficiency (WUE) with manure and cover cropping.

GRANT PONTIFEX WITH HIS BROTHER BEN, HOLDING DAUGHTER QUINN, AND FATHER NEIL PONTIFEX FRAMED BY A HEALTHY CROP OF CANOLA.

"This is important for all producers because it has the potential to enable ongoing profitability despite the declining terms of trade in agriculture.

"I also wanted to look at more efficient ways of applying and getting the most out of manure as well as cover cropping in low rainfall environments, where it's not very common.

"My Nuffield study has helped me learn more about the role of soil biota, which I believe is important to understand in order to improve the soil food web functionality. I have also learnt diversity is important in cropping systems."

While Grant is still in the early stages of writing his scholarship report, he feels his research has enabled him to understand, reflect on and change the way he farms and manages soil health; something he hopes he will also be able to convey to other growers.

"I have always enjoyed hearing from previous Nuffield scholars about their travels and have wanted to do my own

research for a while," he said.

"My scholarship has given me the opportunity to learn from others and to gain insight into production systems that are more resilient and ultimately more profitable than the ones we are currently using.

In four months of travel over eight months Grant visited the Netherlands, Ireland, United States, Canada, Mexico, Brazil, France, United Kingdom, and New Zealand; meeting with entrepreneurs, farmers, researchers and successful business owners in an effort to learn how producers in those countries are tackling the issue of soil health.

What he learnt is that 'carbon is king'.

"Carbon is the most important element in the soil for crop production," he said.

"Crop nutrient cycling and maintaining adequate soil cover depends on the composition of the residue. The carbon ratio of different plants is important when considering a crop rotation that will feed the soil microbes and supply armour to the soil.

MEETING 'GREAT PEOPLE', INCLUDING THE 2018 NUFFIELD SCHOLARS [PICTURED] AND OVERSEAS RESEARCHERS AND INDUSTRY LEADERS, HAS BEEN A FEATURE OF GRANT'S NUFFIELD EXPERIENCE.

"There is potential to build soil organic carbon (SOC) in grain production systems by planting cover crops after winter cash crops; although this will be dependent on moisture availability after harvest. Perennial species under-sown with cash crops could maintain living roots after cash crop removal."

Grant says chicken litter is high in organic carbon and a good manure to apply.

"The poultry industry will continue to grow as chicken becomes more popular as an economical, versatile meat, so there will be more manure available for use in broadacre cropping fields.

"A real opportunity exists to value-add this waste product and to benefit our soils and the environment. We just need to know more and develop best management practice for the use of chicken manure in broadacre grain production."

Grant has also researched the benefits of cover cropping to ascertain if covers are beneficial every year or only as an opportunity crop in a wet summer and to determine if they promote an increase in soil biology, nitrogen fixation, nutrient cycling and mineralisation.

He is of the opinion that, in most parts of SA, summer cover cropping is most likely to be successful in years with above average summer rainfall, and sees a need for covers grown within a winter cash crop rotation to be terminated prior to grain fill to limit water use, especially in low rainfall regions.

"The role of a cover crop is to cover the soil, reduce erosion, capture moisture, feed the biology, suppress weeds, and cycle nutrients. Only heavy cover crop residues will provide an allelopathic environment to reduce the emergence of weeds.

"Cover crops can also help manage nitrogen, with high-carbon plants such as summer grasses able to provide good soil cover and high-carbon residue following a low-residue legume crop.

DURING HIS OVERSEAS STUDY TOUR, GRANT HAD AN OPPORTUNITY TO CHECK OUT THIS MACHINE, WHICH ROLLS STANDING VEGETATION ONTO THE SOIL AND SOWS A FOLLOWING CROP IN A SINGLE PASS.

"Interestingly, I learnt in my travels that multi-species covers that include warm and cool season grasses and broadleaves are better than single-species stands.

"Living plants build carbon. Cover crops, like cash crops, produce green leaves, which produce sugars for the plant. These sugars feed microbes in the soil, which then unlock nutrients from soil organic matter to feed the plants. If there are no living plants, as is the case with a fallow, the microbes will eat crop residues and then organic carbon reserves to stay alive.

"Covers need to be terminated at flowering to retain water for the following cash crop but fallow periods need to be eliminated from cropping rotations if we are to build soil organic carbon."

Grant has conducted three cover cropping trials over several years with no conclusive results.

"I have not seen any difference in yield of the following cash crops and I don't expect to for a while. Cover cropping is about improving soils by adding more carbon more often to keep soil biology alive. Improving soil carbon and water use efficiency (WUE) will only happen over many years.

"I have seen cover cropping in rainfall environments similar to South Australia's working successfully around the world and am convinced regenerative systems including cover crops can enhance soil health successfully in this State. The key is to find the right cover crop species and combinations that tolerate dry, low-humidity climates, which will need further investigation.

THE PONTIFEX FAMILY'S AIR TRACTOR IN ACTION APPLYING A CHEMICAL TO A CROP OF CANOLA.

"There are many different cover crop species available and the selection or combination will vary depending on why the cover is being grown. Some plants are more drought tolerant than others, produce more carbon, cycle more nutrients or can help alleviate compaction better than others."

What Grant learnt is that 'carbon is king'.

Grant believes summer cover cropping in SA can be successful, but summer covers might not be the only option for SA growers.

"At the moment I am considering whether we could grow a cover crop over winter, terminate it in spring and follow that with a higher-value summer crop for harvest."

He suggests other farmers give cover cropping a go and try different species, not the same crop every year.

"Have a go, and try six to eight different species in mix," he said. "Plant after a 25mm summer rain event. Have a reason for doing it and an end goal. For instance, plant C4 summer grasses in a mix after lentils to provide more ground cover and terminate them before grain fill to preserve moisture and prevent seed set."

Grant farms in partnership with his brother Ben, who manages two properties on Kangaroo Island: a 2,300 ha farm at American River and a 2,300 ha property at Vivonne Bay.

"The different locations spread our seasonal rainfall risk and give us a greater commodity spread. We share harvest machinery, labour and our spray plane but those are the only opportunities for scale efficiencies because all other operations happen at the same time.

"At Paskeville we use a Khart disc, Sonic boomspray, three CR 9.90 combines and a Shelbourne stripper head. On Kangaroo Island we have a Tobin Bullet disc, Nitro boomspray, a delver and the Air Tractor plane.

"We also have on-farm storage at both properties; 2,000 tonnes on Yorke Peninsula and 1,000 tonnes on Kangaroo Island.

"Logistically it is very difficult to farm in locations that are 300km apart and separated by water, but reliable, frost free, high rainfall country on Kangaroo Island

is well priced and our KI holdings complement our equity base on Yorke Peninsula."

Average rainfall across the brothers' three properties ranges from 400mm a year at Paskeville to 600mm annually on the Kangaroo Island properties.

"The soils are quite different as well," Grant said. "On KI we have buckshot ironstone gravel over clay and some sand over clay with a pH of 4.5-6. On Yorke Peninsula we have clay loam and some loam over limestone with a pH of 7.5-8.5."

In 2018 he sowed wheat, lentils, barley, linseed, chickpeas and oaten hay on the Paskeville property, where he applies chicken litter at a rate of 2.5t/ha every year and mushroom compost from time to time.

He has been using no-till methods for some years with the aim of improving soil health but has come to the conclusion that 'no-till with no cover is no good'. "No-till is essential to maintain the soil food web but needs to be integrated with good soil cover to keep soil temperature low enough to reduce evaporation and enable soil biota to survive.

"The future for us involves more diversity, healthier more productive soils, better WUE, and more nutritious food production."

Grant has already made changes to his farming operations on the basis of what he has learnt from his Nuffield research.

"Despite practicing no-till, retaining all crop residues for the soil and applying chicken manure on an annual basis we haven't been able to build our soil organic carbon (SOC) much beyond 2.5% with our current system of annual winter cropping.

HAVING DIFFERENT GROWING CONDITIONS AND MATURITY TIMES ON THE PONTIFEX FAMILY'S YORKE PENINSULA AND KANGAROO ISLAND PROPERTIES SPREADS SEASONAL AND PRODUCTION RISKS AND ALLOWS MACHINERY AND LABOUR TO BE SHARED AT HARVEST.

"Growing more roots more often through diverse cover crop species in combination with annual cash crops will fix more carbon from the atmosphere into our soils and produce more carbon residue to feed the biology.

"To significantly increase SOC we need to grow more carbon, which means growing high-carbon plants more often and fewer legumes, which have a low C: N ratio.

"We are growing less legumes and more grasses that are higher C:N ratio plants. The residue of plants containing more carbon lasts longer so there is more food for microbes, and more cover means less evaporation. This year we will plant dry-tolerant species that have low water requirements and will possibly plant winter covers followed by a summer cash crop."

Grant says his scholarship, which he found a huge commitment but extremely rewarding, provided him with an opportunity to learn more about a topic he has been working on for more than 12 years.

"I feel privileged to have been given this opportunity and to have met so many great people who will have a lasting impact on my life. I have enjoyed the experience immensely and am extremely grateful to Nuffield Australia and my investor Nufarm Australia.

"It has made our business more resilient, encouraged employees to take on greater responsibility and broadened my knowledge of different farming systems."

More to perennial cereals than yield

GRAEME JENNINGS

Researchers involved in a global project to develop perennial wheat and other grains have registered strains of perennial wheatgrass as Kernza, but this new crop, which is being grown commercially in the US, is a long way from wheat in every way.

Growing perennial wheat – or any perennial grain crop – would require a farming system dramatically different from current dryland cereal production systems; a fact acknowledged by those involved in the perennial grains initiative.

While plant breeders are striving to develop commercially viable perennial grains, others are working on ways to integrate perennial cereals into farming systems.

Perennial wheat has attracted attention in Australia but efforts are underway to also develop perennial forms of rye, sorghum and rice. Much of this work involves crossing annual commercial cultivars with closely related wild perennial relatives, mostly wheat grasses, in the case of wheat; a process similar to that used in the development of triticale.

There is also a parallel, complementary strategy of domesticating wild perennial plant species with the potential to become grain crops. Species in this program include ***Helianthus maximiliani*** and ***Silphium integrifolium,*** two relatives of common sunflower, and intermediate wheatgrass, a perennial relative of wheat reported to be good pasture and produce high-protein grain.

Improved lines of intermediate wheatgrass have been registered as Kernza® and grain from this new crop is being used commercially in US restaurants, bakeries and for brewing.

The global interest in perennial grains, and Australian work with perennial pastures and forage shrubs, is driven largely by concerns about soil degradation associated with intensive cropping practices based on shallow-rooted, annual species that have displaced the predominantly deep-rooted, perennial vegetation that existed before the land was cleared for farming. Specific issues include salinity, groundcover maintenance and seasonal feed gaps.

In the US, where farmers are facing much the same environmental issues as Australian producers for much the same reasons, the Kansas-based Land Institute is a major player in the effort to develop perennial grains as part of its goal of developing Natural Systems Agriculture 'with the ecological sustainability of the prairie and grain and seed yield comparable to that of annual crops'.

NSW DPI RESEARCHERS MATTHEW NEWELL (LEFT) INSPECTING PERENNIAL WHEAT PLOTS AT COWRA WITH DR THARCILLA ARVARENGA AND DR GORDON REFSHAUGE.

As with any cross-breeding program using genetics from wild species to alter the characteristics of commercial crops, achieving acceptable grain characteristics, yield and quality in perennial cereals is proving a major challenge, with the annual yields from current wild x domestic crosses and wild species undergoing domestication lower than those from annual grain crops. However, according to NSW Department of Primary Industries Senior Research Scientist Richard Hayes, there are indications that yields of perennial wheat increase as a stand matures and researchers are optimistic that yields of perennials will compare more favourably with those of current annual varieties once better-adapted material is available and yield performance can be compared over multiple years.

Australia has been exploring the potential of perennial wheat for some years. Current Australian work is being co-ordinated from Cowra, in NSW, with NSW DPI researchers having trialled more than 200 perennial lines, some grass x wheat crosses and some improved wheatgrass lines including several registered Kernza selections from the US.

Under Australian conditions Kernza lines have proved to be longer-lived than hybrid wheats but much less vigorous during the establishment year, with grain that is only a sixth the size of wheat.

The Cowra work is largely focused on the potential of perennial wheat as a 'dual purpose' crop providing grazing and opportunistic grain production; an approach being increasingly adopted with annual winter wheats in higher-rainfall areas of NSW.

Matthew Newell, one of the NSW researchers involved in the project, suggests that 'dual-purpose' cropping systems based on perennial varieties could help farmers better manage climate variability by making farming systems more flexible and easier to adapt to changing environmental conditions. In

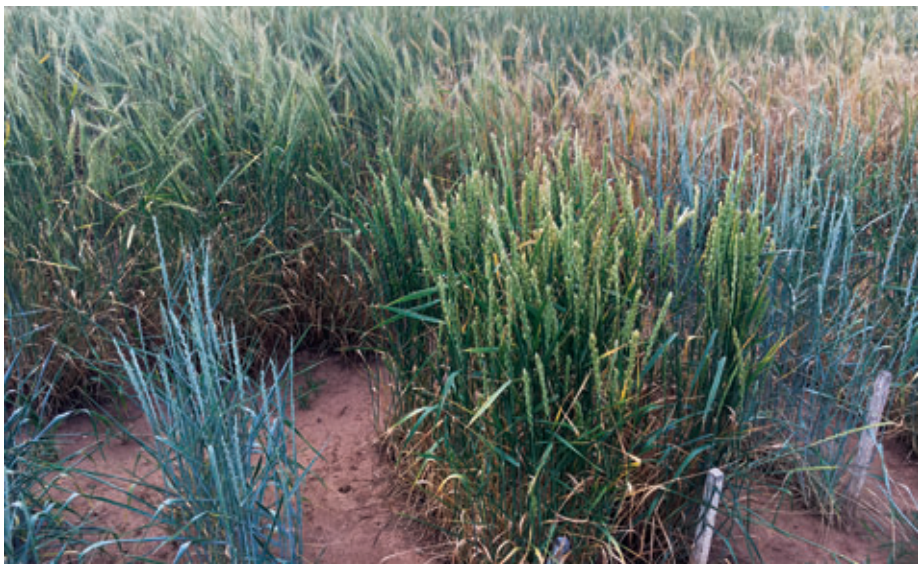
marginal cropping areas, perennial cereals could enable farmers to reduce inputs and costs, improve water-use efficiency and use out-of-season rain while providing environmental benefits such as reducing acidification, salinisation and soil erosion.

Cornell University scientist Matthew Ryan, in a paper titled 'Managing for Multifunctionality in Perennial Grain Crops', places more importance on the environmental and ecosystem benefits of having perennials in farming systems than on their grain yield potential.

For example, growing perennial grains for several years before growing annual crops, a concept similar to the well-established practice in parts of southern Australia of alternating phases of grass-based pasture and cropping, could improve soil health, he suggests, and where erosion or water quality is an issue perennial grain crops can be grown on slopes or as a buffer crop along field edges to reduce soil erosion and nutrient losses.

In annual cropping systems it is common to rotate crops to manage weeds, pests and disease and to improve soil, while planting cover crops between commodity grain crops can have beneficial effects on soil biology and soil physical properties. Planting areas to perennial grains and inter-cropping with annuals has the potential to provide many of the benefits gained from wide seasonal rotation of annual crops, while harvesting or grazing vegetation from perennials can reduce certain pest problems as well as generate income.

In SA and Victoria, Mallee Sustainable Farming [MSF] is exploring how to reduce the risk posed by saline scalding from 'seeps' caused by water draining off sandhills, an issue projected to impact more than 20,000 ha in the SA and Victorian Mallee within a decade unless it is addressed.



PERENNIAL WHEATS, AND OTHER PERENNIAL CEREALS, COME IN MANY SHAPES, SIZES AND COLOURS. ONCE PLANT BREEDERS DEVELOP OR SELECT A LINE WITH ADEQUATE COMMERCIAL AND CULTURAL CHARACTERISTICS THE NEXT CHALLENGE WILL BE HOW TO INTEGRATE IT INTO FARMING SYSTEMS.

This four-year initiative aims to identify areas at high risk of saline degradation due to sub-surface drainage down slopes, devise a method to predict where seeps might develop and determine how best to remediate established seeps and prevent new ones developing.

Much of the work around prevention and remediation of salinisation involves use of plants to intercept and use water moving down slopes before it reaches the surface and begins to cause problems. Some of the most successful perennial lines in the Australian perennial wheat trials are derived from tall wheatgrass, ***Thinopyrum ponticum,*** a perennial relative of wheat that is commonly used to reclaim saline land.

In his paper Dr Ryan, an assistant professor in the Cornell School of Integrative Plant Science, identifies potential agronomic and commercial benefits of perennial grain crops as including no or lower annual seeding costs and lower fuel, fertiliser and pesticide inputs than required for comparable annual grain crops and suggests there could be price premiums for grain from perennial crops driven by consumers searching for more 'sustainable' products or characteristics of the grain or seed.

Perennial grain cropping systems will need to be multifunctional, he suggests, a position supported by Dr Hayes, who says multi-functionality will be important in maximising resource-use efficiency because it increases the likelihood of resources such as rainfall being channelled into agricultural product.

Both men identify potential to graze perennial cereals early in the growing season prior to stem elongation and grain development, just as is done with dual-purpose annual wheat. Results from NSW field work show that some perennial wheat hybrids and IWG can withstand early defoliation with only a modest reduction in grain yield. Defoliation prior to the first grain harvest, in the first year after establishment, reduced IWG grain yield by 13.3%, the average yield of four perennial wheat

IDENTIFYING PERENNIAL BENEFITS

Visions of a perennial crop that will generate direct income, improve the resilience and sustainability of farming systems and provide environmental benefits ensure the idea of perennial cereals continues to attract considerable interest and research effort.

However, Australian research suggests that perennial pastures and forage shrubs could be of at least equal and possibly greater value than perennial cereals in many farming situations.

Bio-economic analysis has shown that whole-farm profit can be increased by including perennial shrubs as a feed source because grazing of shrubs reduces the amount of supplementary feed needed in summer-autumn when the feed quality of crop residue has declined and allows grazing of annual pastures to be deferred.

Much of the recent work in this field has been done under the banner of EverCrop, a farming-system research project of the Future Farm Industries Cooperative Research Centre that operated from 2007 to 2014.

According to Michael Robertson and Clinton Revell, in a paper on perennial pastures, land degradation issues that have emerged over recent decades have stimulated a renewed effort to incorporate perennial forages into Australian crop-livestock systems.

Drivers for the inclusion of perennial forages in crop-livestock systems include their ability to use of out-of-season rainfall to produce green feed and so reduce the need for supplementary feeding, enable more productive use of marginal land and the possibility of sequestering carbon and enhancing biodiversity outcomes, they say.

Conversely, annual pasture species encourage weed build up, increase the rate of soil acidification and allow unused rainfall to increase deep drainage, leading to increased river and dryland salinity. Annual-based systems also often make it difficult to maintain sufficient cover to protect the soil from wind and water erosion, particularly if dry residues are grazed over summer and autumn.

The authors expect the need for perennials to grow as producers look to mixed crop-livestock systems to manage risk and achieve better natural resource management outcomes. However, despite the benefits of and opportunities for perennial forages in crop-livestock systems and the issues arising from on-going use of annual pasture species, the use of perennials has been constrained by a lack of well-adapted species and perceived difficulty in establishing and removing perennial species from cropping paddocks.

A large range of alternative perennial legumes has been evaluated in Australia but few have proved as productive as lucerne; currently the only perennial legume widely grown in the crop-livestock zone, predominantly in phase rotations in eastern Australia.

Short-lived perennial herbs such as chicory and plantain are recognised as valuable species for finishing livestock, they say, but have rarely been considered as serious options for the mixed crop-livestock zone. However, the performance of these two species in field evaluations suggests their role in mixed farming systems should be reconsidered by growers in temperate regions.

Saltbush ***(Atriplex spp)*** is the most widespread browse shrub used on mixed farms in southern Australia but recent research has focused attention on the potential of other Australian perennial native shrub species including A***cacia*** and ***Rhagodia,*** another saltbush species, in medium to low rainfall districts.

Integration

Australian mixed farming systems are typically dominated by annual species but perennial forages and shrubs are used in a variety of roles and the EverCrop team identified a variety of approaches that can minimise the apparent conflict between increased use of perennials and the dynamics of an annual-based cropping system and enable integration of perennials into mixed crop-livestock enterprises.

These approaches are characterised as rotate, separate or integrate.

In this context 'rotation' involves sequences or 'phases' of pasture and crop production on the same area of land, such as a multi-year stand of lucerne followed by several years of grain crops or grain-canola rotation.

The authors identify several potential trade-offs between cropping systems when growers rotate perennials and annuals. These include drier soil profiles at the end of the perennial phase, which can result in lower yields of following crops, and the expense of removing perennial forages at the end of that phase. There is greater risk of poor establishment and out-of-season growth of perennials is generally difficult to predict, they require a higher level of grazing management than annual pastures or cereal stubbles and the residues of many perennials, including lucerne, are slow to break down and can tie up soil N needed by a following crop for early growth, they say.

Shrubs such as tagasaste and saltbush are not options for phase farming but are well suited to a 'separation' approach. They are best used as permanent forages and are often grown in strategically positioned block plantings, frequently on moderate- or poor-yielding cropping soils, to achieve environmental objectives such as disrupting rainfall runoff to prevent erosion or intercepting and using sub-surface water to avoid development of saline seeps.

Tagasaste and saltbush are also suited to use in wide-spaced alley systems with annual crops grown between them; technically a hybrid form of incorporation between separation and integration.

Integration, also categorised as synchronisation, involves growing a perennial and annual simultaneously on the same land, typically by 'pasture cropping', which usually involves under- or over-sowing with an annual species or relay sowing forages with crops.

All this suggests growers calculating the benefits of having perennials as part of their farming system should take a holistic approach and look beyond immediate cash returns from grain and grazing to take account of indirect or deferred benefits such as soil improvements, management benefits like weed control opportunities, wider environmental benefits, eco-system services and risk management.

hybrids by 8.1% and the yield of annual wheat by 30.3%. However, the grain yields of the perennial lines were still considerably less than the yield of the annual wheat. Dr Hayes points out that these results were achieved with young stands of poorly-adapted perennials.

In addition to producing grain, perennial crops offer unique opportunities for multi-functional agriculture that combines production of agricultural products and non-market goods and services including ecosystem services, Dr Ryan says. Year-round vegetative cover can help regenerate soil health, provide a buffer to reduce soil erosion or protect water quality and reduce fertiliser nitrogen (N) requirements. Soils in perennial cropping systems also typically have good water infiltration and retention rates, which decreases runoff and soil erosion.

Increasing diversity by intercropping or growing a mixture of different species can increase yield stability, enhance biological control of pests and provide habitat for wildlife.

Mixed-species stands maximise the use of resources by crop plants and make it more difficult for weeds to access light, nutrients and water but competition can result in resources being diverted away from the primary crop, which highlights the importance of multi-functionality. Mixed stands also support greater populations of natural enemies that help keep pest insects in check, with predators and parasitoids often present at higher densities in mixed intercropping systems than in monocultures because a diverse mix of plants is more likely to provide floral resources, egg-laying sites, refuges, alternative prey and non-prey food sources.

In-field plant species diversity can also increase production due to greater resource use efficiency and help reduce losses from insect pests through processes such as altered chemical signalling or lower insect feeding efficiency due to increased search time. Grazing or harvesting perennial grain crops for forage can help further suppress pests, with removal of growing vegetation able to help reduce weed populations and removal of residue after grain harvest having the potential to limit disease and insect pest pressure in the following year.

However, there are questions about the performance and productivity of individual species in multi-species stands and the management challenge posed by highly diverse mixed-species stands could limit adoption of this approach, Dr Ryan says.

PERENNIAL RISK MITIGATION

Perennials can contribute to the enterprise diversity that is increasingly being recognised as key to mitigating the seasonal and price risks facing farmers, say Michael Robertson and Clinton Revel in a paper on perennial pastures.

The ability of perennial plants to extract soil water and nitrogen (N) from below the root zone of annual plants, convert rainfall falling outside the annual growing season to green feed and provide more stable groundcover means they have a key role in risk mitigation, they say.

Perennials have the potential to improve surface cover and soil biological activity and reduce groundwater recharge, so they can be used to reduce negative impacts of farming on the natural resource base and enable farmers to better match land-use activities with land capability. There are also indications that perennials can improve nutrient cycling, soil surface condition, water infiltration and the subsoil environment.

Emerging precision-agriculture technologies such as high-accuracy auto-steer guidance systems and remote monitoring capabilities will facilitate the management of livestock in cropping systems and reduce demands on labour and complexity of management decisions, the authors say.

For example, high-accuracy auto-steer will enable fine-scale design and management of planting arrangements for perennial-annual combinations, while remote monitoring of pastures will facilitate feed budgeting and grazing management, enabling more effective management of the feed base.

Similar technologies will also play into livestock management and reduce labour demands for moving livestock and monitoring livestock condition, they predict.

PERENNIAL CEREALS NEED TO GROW WELL ENOUGH TO PRODUCE A GRAIN CROP – OR FORAGE FOR LIVESTOCK – AND STORE ENERGY RESERVES IN ROOTS OR CROWNS FROM WHICH TO REGENERATE THE FOLLOWING SEASON.

Management issues raised by the concept of functionally diverse perennial grain polycultures include how complex a mixture might be to manage, profit stability and the possible need to re-seed or take other action to increase the relative competitive ability of weaker species. Greater diversity of species could potentially restrict herbicide options and require harvesting equipment that can handle multiple grains or green vegetation along with dry grain, he says. However, because farmers can strategically select species based on agronomic compatibility as well as what they offer in a polyculture or intercropping system, it is possible to achieve a high level of ecosystem services while minimising increases in management complexity.

Phase farming - growing a perennial grain crop for several years then a sequence of annual grain crops - is one of the options suggested as a way to integrate perennial crops into modern cropping systems. This approach, which is already widely used with perennial pastures in much of S-E Australia, has the potential to regenerate soils degraded by annual grain crop production because a stand of perennial vegetation can increase soil organic matter content, enhance soil porosity and water infiltration rates, reduce soil bulk density, improve soil biology and increase N cycling.

Over-sowing perennial cereals with legume forages will reduce nitrogen requirements, as will growing a perennial legume such as lucerne and over-sowing with a cereal or other annual crop, Dr Ryan suggests, but Dr Hayes favours establishing a self-regenerating annual legume to coexist with the perennial cereal as the best approach in Australian conditions.

THE 6HA EVALUATION EXPERIMENT AT COWRA LAST YEAR IN WHICH RESEARCHERS COMPARED THE MOST PROMISING LINES OF PERENNIAL WHEAT FROM AROUND THE WORLD IS BELIEVED TO HAVE BEEN THE LARGEST PLANTING OF PERENNIAL WHEAT ANYWHERE ON THE PLANET.

Growing legume forages with perennial cereals, whether in strips or intermixed within rows, can also provide N for the grain crops, facilitate the accrual of soil organic matter and increase forage quality.

However, growing two crops in the same space at the same time is likely to impact the performance of one or both.

Grasses and legumes are compatible functional groups and are often seeded together in perennial pasture systems and for forage production, but in an Australian trial exploring seeding arrangements for experimental perennial wheat lines intercropped with sub clover, clover sown in its own rows beside rows of the perennial persisted better than clover sown with perennial wheat in the same row. Conversely, in an Iowa experiment comparing the performance of three legumes and four grasses, including a forage variety of IWG, as monocultures and in perennial forage crop mixtures, the polycultures were on average 73% more productive than the monocultures.

Replacing annual grain crops with perennial crops can reduce nitrate leaching and nutrient transport throughout the year because perennials generally have larger root systems than the annuals and are in place year round. One 2013 experiment found that total nitrate leaching under IWG was almost half that under annual wheat when both systems were fertilised with 90 kilograms of N per hectare.

Other work suggests that perennials are less likely to require fertiliser N to ensure a good start to the growing season.

In a 2016 paper on plant succession Tim Crews, Director of Research with The Land Institute, points to storage and subsequent internal translocation of N as an important mechanism for maintaining productivity in perennial systems under variable environmental conditions. The ability to take up and store N until it is needed by the plant is key to the ability of perennials to emerge and regrow after a period of dormancy, he says, with mobilisation of stored N providing as much as 50% of the N required for above-ground growth in a full growing season.

This storage of N also limits N losses, a substantial inefficiency in annual cropping systems, which has environmental benefits and is another reason perennial-based systems are expected to need lower fertiliser inputs.

Approximately half the N remaining in the foliage of a perennial at senescence is recycled to support new growth by translocation to roots and crowns that persist through dormancy, Dr Crews says, with N translocated internally from these reserves important in enabling perennials to achieve rapid, early season growth and rapid regrowth following defoliation events.

Biomass harvest prior to senescence, whether by grazing or cutting, or limited soil N availability can reduce the N available for translocation to roots and crowns and so impact on spring growth, so in perennial grains there may be a trade-off between grain harvest and the development of N reserves to support the following year's growth.

Growing a second crop with a perennial cereal can reduce the availability of resources for the primary grain crop and will likely lead to reduced grain yield, according to Dr Ryan. However, if vegetation from the perennial cereal is grazed or harvested for forage, the gains in forage production and quality might offset the losses in grain yield.

Perennial crops are often active for longer than annual crops so perennial grains can use sunlight and rainfall at times when annual grain crops cannot, he says.

Comparisons of perennial and annual forage and bioenergy crops suggest perennial grain crops are likely to extract more water from deeper in the soil profile than annual grain crops because of their extensive root systems, greater primary productivity, longer growing season and greater longevity. In one experiment comparing water use in IWG and annual wheat, moisture levels under the IWG were lower than under annual wheat at depths of up to a metre, suggesting that in medium to low-rainfall areas where growers rely on soil moisture stored over summer to grow winter grain crops, perennial grains could deplete soil water reserves and limit crop persistence and future yields.

Livestock, inputs offer profit potential

SARAH JOHNSON

A nine-year research trial at Minnipa Agricultural Centre has found that livestock can increase the profitability of farming systems in low rainfall areas.

Livestock in mixed farming systems improve productivity and profitability and contribute a variety of other benefits. And they appear to enhance soil biology.

These are some of the key findings from a long-term trial established on SA' s Eyre Peninsula to address the concerns of farmers that livestock were causing soil damage during dry seasons.

Originally titled 'The Impact of Livestock on Soil Health', the study, which ran from 2008 to 2016, was undertaken by a South Australian Research and Development Institute (SARDI) research team based at the Minnipa Agricultural Centre as part of the Grains Research and Development Corporation (GRDC) Grain and Graze initiative.

SARDI Research Officer Jessica Crettenden, who published the results of their work in February 2018, in a paper titled 'The impact of livestock on paddock health: nine-year enterprise study', said the trial was designed to test the validity of the view that grazing had a negative impact on soil health.

"There was a perception that livestock have a negative impact on farming systems and we set out to debunk that and show that livestock have a place in the system," she said.

SARDI RESEARCH OFFICER JESSICA CRETTENDEN.

FIELD DAYS AND REGULAR COMMUNICATION WITH LOCAL GROWERS WERE INTEGRAL ELEMENTS OF THE MINNIPA LIVESTOCK IMPACT TRIAL.

"The trial started in drought years on Eyre Peninsula when a lot of farmers were unsure about how much their livestock were damaging the paddocks and what they should be doing about it.

"They were questioning whether they should be keeping their animals, what they were worth and what damage they were doing, particularly to the soil."

The high input system carried more than twice the stocking rate of the low input system.

Over the nine years of the trial the research team assessed the impact of livestock on soil health and the productivity of crops and pastures and analysed the effect of higher inputs, mainly fertiliser and seeding rates, on soil fertility and productivity.

They also measured the impact of livestock on weeds and pests, water use efficiency and nitrogen cycling.

"We found that not only were livestock not damaging the soil, they were providing benefits," Jessica said. "They're actually doing a fantastic job in farming systems; more than we first thought, like reducing weed and pest numbers and increasing water use efficiency. There's also some sort of nutrient cycling happening in the soil. We don't quite understand that yet, but it's definitely higher where there are livestock than in non-livestock systems."

The trial was conducted on 14ha of sandy loam divided into four 3.5ha sections. Low and high inputs were tested in the first two seasons, before grazing was added in 2010. From then on there was a low input and high input area, each with a grazed and ungrazed section.

The trial was based on a wheat-medic rotation, with 20kg/ha extra wheat sown and up to 20kg/ha extra Di-ammonium Phosphate (DAP) applied in the high-input treatments, plus 67.5kg/ha of ammonium sulphate in the first two years.

The cropping and pasture phases were

synchronised across the trial area, which was pasture in 2010, 2012 and 2015. In 2010, Angel medic was sown at 5kg/ha with an application of 30kg/ha DAP in the high input treatments but no medic was sown in the low-input areas, reflecting the approach of many farmers who rely on self-regenerating pastures.

In the six-year grazing phase of the trial, from 2010 to 2015, the high-input areas provided more than twice as much grazing, measured in grazing days per dry sheep equivalent (DSE), as the low-input areas in each year except 2014.

The researchers measured pasture biomass, grain yield, water use efficiency, total nitrogen, phosphorous and soil organic carbon throughout the trial.

Analysis of this data showed that the high input system was more productive in both the cropping and pasture phases, producing 1.25tDM/ha more medic biomass in the pasture phase and 0.5t/ha more wheat grain yield than the lower input system. The grazed sections produced an average of 0.1t/ha more grain than the areas that were not grazed.

Total nitrogen levels were similar in the low and high input systems but the data analysis revealed more nitrogen in the grazed sections of both treatments, with 17 and 13kg/ha more nitrogen in the low and high input grazed zones respectively.

The trial also showed that maintaining higher inputs over several years had a cumulative beneficial effect; something Jessica believes farmers can learn from.

"I think it's opened up farmers' eyes to the effect that higher inputs can have over time. It may be only a small increase each year, but it adds up.

"Some farmers look at inputs as having an effect only in the year they are applied but we were able to repeat the inputs each year and found there was a build-up from year to year. Every year it got better and better and now there's a big difference between the low input and high input systems."

We found that not only were livestock not damaging the soil, they were providing benefits.

The trial also identified the benefits of higher inputs in medic-based pastures.

"I think some farmers have seen the benefit of re-sowing their medic once every six years and applying some phosphorous but many have never re-sown their medic, so a lot of their medics are underperforming. They don't have the seed bank there that they really need and haven't tapped into the new varieties that are available. They are relying on old varieties to fix the same amount of nitrogen as the new varieties do, which is not going to happen.

"Farmers are now starting to think that if they want the most production out of their pastures they have to actively look after their self-regenerating systems and not just leave them to take care of themselves."

The level of soil nitrogen and nitrogen cycling under grazing deserves more investigation, according to Jessica.

"It seems that grazing increases nitrogen cycling in the soil, but it's quite a complex process that appears to be influenced by livestock walking over the soil, what they remove and what they put back. It's all about the removal of the biomass and returning it in a different form."

The Minnipa trial is continuing as part of the national Dryland Legume Pasture Systems (DLPS) project funded by the Australian Government Department of Agriculture and Water Resources, GRDC, Meat and Livestock Australia (MLA) and Australian Wool Innovation (AWI). SARDI will lead the southern region project in a research partnership with the GRDC, MLA, AWI, CSIRO and Charles Sturt University (CSU).

Continuation of their work means the Minnipa team are now pursuing the issues around N cycling under grazing and are working to better understand the effects of livestock on pests, weeds and increased biomass that were identified in the 2008 to 2016 study, which showed that grazed treatments had lower snail and mice populations, more ground cover outside of the growing season and reduced summer weed height and density.

"We want to keep the project ticking along and try to focus on some of the results we didn't understand before," Jessica said.

"What we saw during the initial trial was that, in summer, when the snails were retreating up on the stubbles, grazing livestock acted like a prickle chain. They smashed the stubble down, which removed the habitat for the snails to camp and survive on and reduced snail numbers.

"It was similar with the mice. The sheep were breaking up the mouse habitat, whereas in the ungrazed systems there was plenty of residue left for them to hide in and feed on.

"Even though the grazed and ungrazed paddocks were right next to each other, we could see that grazing had an impact. Mice and snails would come back to where they were the year before, but there were definitely lower numbers in the years after grazing.

The field data from the trial were used in an economic analysis of the different treatments, the results of which made a big impression on local farmers, Jessica said.

"I was reporting the trial results to

farmers in the area every year, but they were surprised by the results of the economic analysis, which covered the whole trial period. We had drought years, some really booming years and some average ones during the trial and the farmers were shocked at the difference livestock and different input levels could make over a range of seasons."

The economic analysis used gross margins for each year of the trial, rather than an average across the trial period, that were calculated using the PIRSA Gross Margin Guide developed by Barry Mudge in a project funded by SAGIT, Rural Solutions SA and GRDC.

The analysis showed that, over the nine years of the trial, grazing contributed $328/ha in the low input treatment and $725/ha in the high input treatment, with $274 in the low input system and $651 in the high-input system attributed to grazing medic in the pasture phases. The remainder was attributed to grazing wheat stubbles over summer and autumn.

Increased profits year after year showed the benefits could be sustained over a range of seasons.

During the pasture years the high input grazed system achieved a profit of $525/ha, while the high input ungrazed system made a loss of $127/ha. A cost of $99/ha to improve pastures in the high input systems was offset by improved livestock production.

The low input system also showed an economic benefit from grazing, with the grazed section achieving a profit of $208/ha and the ungrazed section making a loss of $66/ha.

THE TRIAL SITE IN ONE OF THE CROPPING YEARS. THOSE VISUAL DIFFERENCES CARRIED THROUGH INTO THE FINANCIAL ANALYSIS THAT REVEALED BENEFITS FROM LIVESTOCK AND HIGHER INPUTS IN LOW RAINFALL FARMING SYSTEMS.

The profits from wheat yields in the six cropping years – 2008, 2009, 2011, 2013, 2014 and 2016 – were better in the high input systems despite the input costs, which were $394 more than in the low input system. The high input system returned a profit of $5,719/ha over the period of the trial, $1,072 more than the $4,647/ha from the low input system.

The comparison showed that returns could be increased by running sheep – a profit increase of $51/ha a year over the income from a low input, crop only system – or increasing inputs, which in the trial returned an extra $49/ha. Adding sheep and increasing inputs boosted returns by $155/ha.

The economic results exceeded Jessica's expectations.

"I didn't think it would be that much. And the fact that the increased profits year after year showed the benefits could be sustained over a range of seasons."

According to the trial summary, the Minnipa team's work showed that integrating livestock into a cropping system can improve productivity and profitability without damaging soil health and that higher inputs could increase the productivity and profitability of mixed enterprise farms in low rainfall districts.

The high input system carried more than twice the stocking rate of the low input system over the trial period and was more productive in the cropping and pasture rotations, which implies many mixed farming systems could be made more productive and lucrative than they currently are.

An eye for e-agriculture

KATHERINE MAITLAND

Modern-day farmers have access to technology, tools and techniques few could even have imagines until very recently.

And the scope and capabilities of these innovations are growing as broadband and internet connection and satellite connectivity options become more widely available and reliable in rural areas.

Fifth-generation Crystal Brook farmer Andrew Sargent is looking to take his understanding and use of this new technology to the next level by learning more about the Internet of Things (IoT) and digital devices that will help him and other farmers benefit from it.

He is undertaking a Nuffield Scholarship, supported by the Grains Research and Development Corporation (GRDC), to investigate how farm sensors and the IoT can improve the efficiency and profitability of cropping and mixed farming enterprises.

> **I think markets will become more volatile and margins will become smaller.**

According to Andrew, who is passionate about managing the land and how new sensor technologies can improve weather observations and on-farm monitoring and decision making, the IoT refers to the billions of digital devices around the world that are connected to the internet and able to collect and share data.

"I am motivated to learn new things and have a keen interest in technology," Andrew said. "I have been following the progress of the IoT for a while and decided to use my scholarship to investigate farm sensors and the IoT because it is new area with not a lot of information about it readily available."

As part of his Nuffield study Andrew will travel to Europe to learn from the best in the world on this subject.

"I plan on travelling to the Netherlands, which is leading the way in the free roll out of IoT networks that are currently used for smart-city and environmental monitoring, and visiting leading research institutions in Europe and agtech start-ups in the United States."

ANDREW SARGENT BELIEVES DIGITAL TECHNOLOGIES AND THE INTERNET OF THINGS HAVE THE POTENTIAL TO IMPROVE GROWERS' DECISION MAKING AND PROVIDE MULTIPLE BENEFITS FOR AGRICULTURE. (PHOTO BY TABITHA RUNKEL PHOTOGRAPHY)

He hopes to discover how new sensor technologies can improve weather observations and inform the decision-making process when it comes to climate variability, as well as reduce staff costs and monitoring times.

"Farmers can use the IoT to optimise the use of inputs, improve water use efficiency, monitor crop losses through disease or weather and better plan for farm activities," he said.

"With the increasing popularity of IoT and connected devices the price is decreasing and there are other network options so farmers are no longer reliant on the mobile phone network."

Andrew believes sensor technology will play an important part in the e-agriculture.

"To increase the scale of our operation we'll need to utilise new technologies to bolster current practices. There's a lot of interest from Australian farmers in sensor technology but we're lacking the knowledge and confidence to implement it successfully on farm.

"Sensor technology opens up a host of benefits for the food and fibre supply chain, for industries from grains right

through to livestock and viticulture. I hope my findings will provide insights that will enable farmers to collect more regular and accurate data to inform their decision-making and look forward to presenting them to industry.

"There is a lot of hype about IoT at the moment and some of it will not be lived up to. It is still a developing concept so there is a lot of change happening. How it looks now is not how it will look in a few years' time but there are a lot of opportunities for agriculture to benefit from it."

When he heads overseas Andrew will leave his farm in the capable hands of his parents, Malcolm and Jane.

The family have been using no-till farming methods since 1999, and in 2018 planted 2,000ha of wheat, barley, lentils, canola and oaten hay.

> **I believe sensor technology will play an important part in the e-agriculture.**

"I believe no-till farming produces a more resilient farming system, allowing the farm business to be more tolerant of the ups and downs of farming," Andrew said.

"In 2018, we grew Scepter wheat, Compass and Spartacus barley, Hurricane and Jumbo 2 lentils, two canola varieties (44T02 and 44Y89) and Mulgara oats.

Andrew says the family are glad to farm in Crystal Brook because it has reliable rainfall (400mm annual average), good soils and good access to markets.

"We have sandy loam to loamy clay soils and generally operate on a three year crop rotation of wheat, barley and a break of either canola or lentils. In the past we have also used field peas and beans as break crops.

"In some paddocks with grass weed issues we will grow a sequence of wheat, barley, oats, lentils, canola, which allows us to maintain pressure on the weeds in successive years and achieve a good reduction in grass populations.

"We have some issues with brome grass and ryegrass in cereals and with tares and bedstraw in lentils and are using IMI-tolerant varieties, which increases our herbicide options, harvest weed seed control and crop rotation to manage them.

"Most of our grain is delivered into a silo system, with some going to container packers or domestic end users.

"We have seed storage and a few hundred tonnes of shed storage on farm for short-term harvest-time storage. We have used grain bags in the past and would use again if the need arose.

"We aim to manage price risk by using swaps and forward contracts, and by growing a range of crops. We have several blocks that are some distance apart and seasonal risk is mitigated by that geographic separation."

In the past 10 years the Sargent family have improved their management practices and kept abreast of developments in farm machinery and weed and disease management.

"We aim to maintain modern equipment so we have access to the latest technology and as little down time for maintenance and repair as possible during critical periods," Andrew said. "We also trial new technology as it becomes available and last season trialled implement-steer on our seeder."

"Currently we have a Flexi-Coil air seeder

DONE AND DUSTY. THE SARGENTS' NEW HOLLAND HARVESTER AT WORK IN A LENTIL CROP ON THEIR CRYSTAL BROOK PROPERTY.

ANDREW SARGENT CHECKS THE QUALITY OF HIS LENTILS, WHICH ARE A PROFITABLE CROP AND PROVIDE MULTIPLE MANAGEMENT BENEFITS.

with knife points, which carry root boots, and press wheels on 300mm spacing. We also run a self-propelled Miller Nitro sprayer with an air boom and a New Holland CR harvester.

"We attend cropping field days regularly and are active members of local grower groups, which keeps us informed of improvements in farming practices.

"We regularly trial new varieties side by side and have trialled an Integrated Harrington Seed Destructor, narrow windrow burning and chaff lining for harvest-time weed seed control. We are yet to see the results from this comparison but aim to implement some form of harvest-time weed seed control into our farming system if the trial results show this approach is successful.

"We are currently trialling bio solids and deep ripping as a means of improving compacted soils, and based on our observations from 2018, ripping seems to have also reduced the impact of non-wetting sands. At this stage we haven't seen any benefit from bio solids but the lack of rainfall last winter may have limited how much was moved into the soil. In some soils we have seen significant yield improvements from deep ripping in the first year after treatment."

Overall, Andrew is optimistic about the outlook for farming.

"I think markets will become more volatile and margins will become smaller, but there will still be opportunities for successful, well-managed farming businesses," he said.

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