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Edition 1, 2019

THE FURROW



Out bush

Celebrating Australia's outback



Learning robotics from John Deere volunteers is one of many ways students are encouraged to become innovators of the future.

Inspiring the innovators of the future

Something most people don't know about John Deere is how active the company is in community service.

Sure, Deere provides grants and donations, but just as important is how the company supports employees who donate their time to help their communities. Last year, employees – even retirees – gave 158,000 volunteer hours of service, a phenomenal number for any company.

About 20 percent of those hours went into INSPIRE, a very special program for John Deere. INSPIRE is Deere's effort to encourage and help children, from primary school through to high school, to appreciate the skills used in STEM subjects – science, technology, engineering, and mathematics.

With those topics, it was natural for John Deere employees to help. "A lot of

our workforce is working in a STEM-related job," says Pat Barnes, program director for Global Youth Education at Deere. "Probably over 50 percent actually have degrees in STEM."

ENCOURAGING SKILLS

INSPIRE, which started in 2011, is a way for John Deere and its employees to encourage and help teach the next generation of innovators.

"We think having a well-educated, diverse workforce with the necessary skills is important in our home communities around the world," says Pat. "Innovation is one of John Deere's core values."

It's no wonder that many students who participate – whether it's building robots, coding computers, or learning how important teamwork is to winning

the various competitions – say their goal is to one day work at John Deere.

INSPIRE opens doors, as it did for Haley Dunn, a student in Iowa in the United States, who participated in an "Introduce a Girl to Engineering Day."


"You really have to include everyone if you want to win," she says of an INSPIRE competition she participated in. "It makes me feel like I can do it instead of being told I can't because I'm a girl." It is connections like these that make John Deere employees realise their volunteer hours are worthwhile.

John Deere spends over \$1m to support INSPIRE. But it's the volunteer efforts of employees who personally connect with children like Haley Dunn.

And yes, these children are inspired. To date, INSPIRE has mentored more than 50,000 students in six countries. ■

CONTENTS

THE FURROW | Edition 1, 2019 | JohnDeere.com.au | JohnDeere.co.nz

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- 4 Breeding in the fast lane**
Rapid flock rebuilding after bushfire.
- 9 International Notes**
Manufacture, mechanisation and soil.
- 10 Time lapse lessons**
Photos used to record crop growth.
- 12 Lending land to lend a hand**
Helping refugees settle in.
- 14 Agriculture & Research**
Dairy feed, herbicides and grapes.
- 16 Farming straight up**
Horticulture's vertical future.
- 26 Worm farm gets a wriggle on**
Turning waste to fertiliser.

- 30 Farming without rain**
Growing high-protein microalgae.
- 34 Hemp a healthy alternative crop**
Agronomic and medical benefits.
- 38 Hop to it!**
Specialty cultivars for craft beer.
- 44 Making the connection**
The internet of things on the farm.

COVER

A photographic journey across some of rural and remote Australia's biggest properties.
Out Bush: photo essay – page 20

The Furrow

Australia/New Zealand edition

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Breeding in the fast lane

With so many farmers in Australia facing the prospect of rebuilding after the impact of fires, droughts and floods, a family working to recover from a catastrophic bushfire almost four years ago shares their experiences – including the remarkable rebuilding of their prized sheep stud.

By Liz Harfull

November 26, 2015, was the worst day of Troy Fischer's life. It was the day he faced the horrific task of shooting what remained of an elite White Suffolk stud flock that his family had spent more than 25 years breeding.

All of the adult flock had been horribly burnt in what became known as the Pinery bushfire, which tore across 82,500 hectares of mostly farm land in the Lower Mid North of South Australia. In a matter of hours, the catastrophic event killed two people and injured 31 others, destroyed more than

90 homes and 400 farm structures, and resulted in the deaths of more than 70,000 livestock, including poultry, sheep, cattle, pigs and horses.

When Troy returned to the family property at Wasleys, about 70 kilometres north of Adelaide, most of the family's 650 stud rams and ewes were still alive, but they were so badly injured none of them could be saved. "The whole breeding flock was gone," he says.

An old hand suggested it would take the Fischers 10 years



Photo: Brian Fischer

1 An aerial view of the coils of ploughed earth created by the Fischers to prevent erosion after the Pinery bushfire.

» We did a lot of soul searching within a few days of the fire to work out what we were going to do. We decided to rebuild, although it wasn't crystal clear at the time how we were going to do that. « *Troy Fischer*

to rebuild their stud flock, ranked among the top 10 in Australia. In a tribute to the family's determination, hard work and state-of-the-art breeding technology, they achieved it in just two years.

The Fischers have been farming at Wasleys since the early 1900s. Today, the enterprise encompasses about 1,300 hectares, including leased and agistment land. Around 600 hectares is cropped annually to wheat and barley, and about 200 hectares of pasture is renovated every year for the

expanding stud flock of 700 stud ewes, which last year dropped 1,000 lambs.

The Ashmore Stud was founded in 1989 after an eleven-year-old Troy convinced his parents to purchase a stud ram and two ewes. "I had a passion for genetics, from a really young age," he says.

Keen to learn more, he moved to Armidale in New South Wales and studied rural science at the University of New England, recognised internationally for research into livestock breeding. After gaining a PhD in sheep genetics, Troy worked for Australian Wool Innovation in Sydney, before taking his research managing skills to the Grape and Wine Research Development Corporation, based closer to home, in Adelaide.

Following a short stint in the commercial wine sector, in April 2015 he fulfilled a long-term ambition and resigned to work full time on Ashmore with his wife, Nette, and their



Photo: X Fischer

children. Six months later, the Pinery bushfire hit, throwing the Fischers' considered plans into chaos.

"We did a lot of soul searching within a few days to work out what we were going to do. We decided to rebuild, although it wasn't crystal clear at the time how we were going to do that," Troy admits. "The silver lining was that 90 percent of our lambs survived, so we had rams to sell the following year to generate income, and their sisters became the foundation of our future breeding program."

NOTHING BUT THE BEST

Troy was determined to aim for sheep of the same, if not better, quality than they had before, and he didn't want to waste time making a start. So he contacted six of the best studs in Australia and asked each of them if they would be willing to contribute a handful of elite ewes. They all agreed without hesitation, although the terms varied from an outright gift to lending the ewes for a season or sharing flushed embryos. "It was amazing really. It was the sort of gift that money cannot buy," says Troy.

Within weeks, the Fischers had sourced 20 elite ewes, which were flushed twice, producing 300 embryos. After artificial insemination, a remarkable 80 percent of the Ashmore ewe lambs conceived. "By August 2016, we had dropped 700 stud lambs, and their genetic merit was better than the lambs we dropped the previous year. It rolls off the tongue really easily to say that, but there was an incredible amount of work to make it happen," Troy says.

In the first 12 months after the fire, the Fischers completed

- 2 Some of the first drop of lambs born after the devastating fire, to rebuild the flock.
- 3 Troy Fischer with his daughter Indigo.
- 4 Dr Simon Walker and Dr Jen Kelly from the South Australian Research and Development Institute transferring JIVET embryos into a recipient.

three artificial insemination (AI) and three embryo transfer (ET) programs. Then they took the best of the resulting ewe lambs and tried juvenile in-vitro embryo transfer, known as JIVET. The technique involves flushing unfertilised eggs out of six to eight-week-old ewe lambs, fertilising them in a test tube, and then implanting them in a surrogate mother five days later. It's a technology that hasn't been widely used because so far the results have been inconsistent. The Fischers agreed to give it a try after being approached by the University of Adelaide and the South Australian Research and Development Institute.

MEETING THE CHALLENGE

Over two years, the research team flushed 18 females, harvesting a pleasing 600 eggs. About half were fertilised and transferred into surrogates. The end result was just 22 lambs, compared with an average of 60 percent using conventional ET techniques. "The lambs we got were magnificent, so the technology is capable of producing elite lambs, but there were challenges getting the embryos to stick," Troy explains.

Although the numbers were lower than anticipated, the trial notched up a world-first. The initial year generated more



3

embryos than recipients, so the research team froze some of them, and then thawed them out six months later. Eight embryos were implanted, leading to the birth of one lamb – the first ever born from a frozen JIVET embryo.

It was a potentially important breakthrough because JIVET technology usually results in lambs being produced out of season. Being able to freeze the embryos makes it possible for an enterprise to stick with a more conventional breeding time, easing management.

Because of the low numbers of lambs produced, the Fischers have decided not to persevere with JIVET for now, focussing on ET instead. Earlier this year, they got 109 embryos from 12 donors – well above the expected average of six or seven per donor.

Despite the losses, Troy talks about the fire being a catalyst. It gave the Fischers an opportunity to fine-tune the flock's structural traits faster than they had planned, leveraging a wider pool of elite genetics. The immediate repercussions also



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Photo: Nette Fischer



5 Some of Ashmore's stud ewes – the entire breeding flock was destroyed in the Pinery bushfire in 2015.

established an approach to farm management that has been maintained ever since, speeding up expansion of the enterprise and the handover from one generation to the next.

"The morning after the fire, things went into overdrive. The phone was ringing off the hook and people we didn't know were arriving to help. So very quickly we had to divide up the roles, because no single person could keep it all in their head and stay sane," Troy explains.

While Troy's mum, Rhonda, fed the masses and helped to make sure her grandchildren got to school, Troy focussed on the livestock and Nette took on the task of managing the finances and an avalanche of paperwork relating to insurance claims.

THE RIGHT ADVICE

Recognising the importance of seeking and accepting expert advice, the Fischers engaged a consultant during the first two years, to help make decisions about aspects such as equipment purchases, and revising the farm layout to save labour and make it more practical for modern machinery. "It's very easy to spend your insurance money too quickly and on the wrong things, especially when you are not thinking super clearly," Troy admits.

Troy's father, Brian, took on the task of coordinating efforts to replace the property's 35 kilometres of fencing. Within a week of the fire, teams of volunteers from BlazeAid were on the doorstep, and someone needed to manage them. As the only family member with a truck licence at the time, he also had to take responsibility for transporting livestock and supplies.

Brian was also responsible for coming up with a unique solution to manage another issue. Fire destroys groundcover and organic material in the topsoil, leaving it prone to erosion. Workshops advised farmers to plough the ground, bringing clods

of dirt up to the surface to help hold precious topsoil in place.

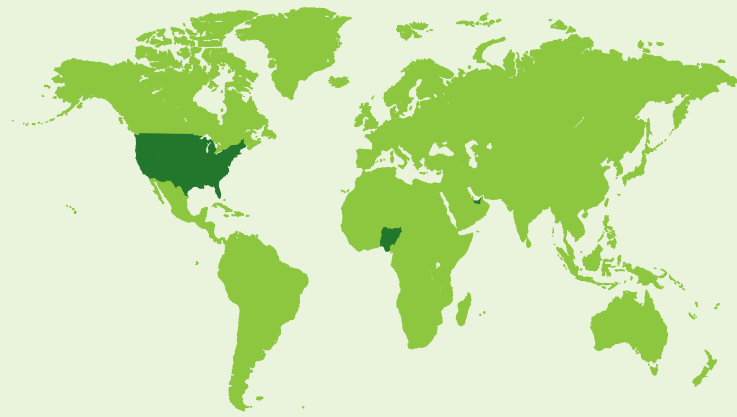
Worried that wind could still blow along straight rows, Brian proposed an approach that his father had used during a bad drought in the 1940s. It involved creating coils or swirls of ploughed ground across the whole farm, with each coil covering about a hectare.

The visual effect was so striking that people filmed it with drones, and a German television crew made contact about making a documentary. "The amount of interest it generated was unbelievable. It looked amazing from the air, and it worked," says Troy. Agronomists have since shared the idea with farmers in drought-affected areas, facing similar challenges.

Looking back at how much they accomplished in such a short time, Troy agrees it might have been better for everyone's well-being if they had taken some time off in the initial stages. "Pretty much the first 12 months were a complete blur," he says.

"Three months after the fire we were exhausted. We worked seven days a week, long hours every day, so we didn't do as well as we could have when it came to looking after ourselves. We did okay, but it might have been better to down tools and go away for a week."

Troy also encourages people to seek professional counselling, sooner rather than later. "It took me a couple of years, but I've since had counselling and I think it's been beneficial. It's a heavy burden that you are carrying and you need to talk to someone, so you can come to terms with things and move on." ■



INTERNATIONAL NOTES



UNITED STATES

Nicole Braniff can look back with pride on a long family tradition working with the green and yellow machines. For 11 years the young mechanic has assembled engines in the John Deere Factory in Waterloo, Iowa, USA. Her great grandfather Fred Heinel worked there with the first generation of tractors. “Whenever I see a John Deere tractor out there, I have to think that I, my father, my grandfather and even my great grandfather had a part in contributing to the machine.” Great grandfather Heinel passed the baton on to his son-in-law Frank Braniff, who encouraged his son, Nicole’s father Larry Braniff to follow the same path. He worked for John Deere for 11 years and was in final audit for the 8000 line, inspecting every tractor before it went to the customer. “I would like one of my children to continue this tradition,” says Nicole. The odds are not bad. Her younger son is already enthusiastic about the robots that assemble the parts in the production line. The Waterloo factory has an eventful past in the history of John Deere. In 1921 the legendary “Waterloo Boy” was already manufactured there. ■



NIGERIA

In Nigeria, the most populous country of sub-Saharan Africa, agriculture is omnipresent. Some 60 percent of the 200 million inhabitants are involved in agricultural production. Farming is still mostly done with manual tools, but this will soon change: John Deere has agreed with the Nigerian Government and the leasing company Nigeria Agricultural Mechanisation & Equipment for delivery of 10,000 tractors equipped with telematics, which will be deployed in smallholder farms through a network of contractors. The 55-83 HP tractors will be delivered over five years and are part of a true agrarian revolution – the Nigerian Government aims to mechanise more than 9 million hectares of land, adding over 2 million direct and indirect jobs through agriculture and creating 37 million tonnes of additional food. This is predominately about cassava, rice, maize, yams, beans and sorghum as well as cash crops like palm oil, cacao, cotton and rubber. John Deere will open an 18 hectare demonstration farm, to teach how mechanisation can achieve higher productivity and potentially yields which are two-to-five times greater than manual farming. ■



UNITED ARAB EMIRATES

When the Norwegian inventor Kristian Morten Olesen watched farmers working hard to get clay into their soil to improve water retention, he wondered how he could simplify the process to improve soils in arid regions. There have been attempts to introduce clay through irrigation but that has led to the formation of a clay crust on the ground surface. Kristian had the idea to split the clay mechanically into nano-sized particles. The result is a homogeneous clay-water mixture, as air bubbles adhere to the mineral particles and make them float. When applied to a soil with 90 percent sand content, the fluid sinks to 50 cm and covers the sand grains with a clay layer, that significantly increases water and nutrient retention. During tests in an oasis in the United Arab Emirates, the water use in tomato, eggplant and okra culture could be reduced by half. The aim of the invention is also to create arable fields and orchards from sand dunes. Kristian has succeeded in cultivating wheat in a levelled desert field. He found that after supplying the “nano-clay”, mycorrhizal fungi settled in the sand. The soil requires a 15-20 percent re-treatment after four or five years if the land is tilled and if untilled then the treatment lasts longer. ■



Time lapse lessons

Recording crop growth provides a unique photographic perspective.

By Larry Reichenberger

1

Time-lapse photography is a simple way to get up-close and personal with a crop. Leaving a camera in the field focused on the plants in a few square feet for part or all of the season visualises how the crop responded to the many conditions it faced – all while you were either busy elsewhere or enjoying time at home with the family.

“It’s more than just a fun way to watch your crop grow,” says Oklahoma, farmer Brent Rendel. “You can also get a lot of information – I always learn something when I’ve set up for time-lapse photos in a field.”

What Brent learned last season was how different winter canola varieties responded to a late-season freeze. “It was early April, the canola was in bloom and the forecast was for snow and cold temperatures. We put a thermometer in the corner of the camera frame and set up solar-powered landscape lights to provide illumination for night-time pictures. The camera took a picture every five minutes around the clock,” he explains.

A part of Brent’s video shows the crop drooping as the temperature drops below freezing, then quickly recovering

the next day. “The temperature got to -3°C and we saw very little damage, although final yields were down. We left the camera in place until late May so we got a five-minute video that shows seven weeks of growth,” says Brent.

WATCHING CORN GROW

Iowa consultant Bob Recker used time-lapse photography to illustrate the importance of the uniform emergence of corn seedlings. “We put the camera out right after planting and kept it in place all season to verify plant-to-plant variations in emergence, growth and yield,” says Bob, founder of Cedar Valley Innovations in Waterloo, Iowa.

Bob’s camera focused on 11 seeds planted in two rows and took pictures every half hour during daylight hours. Each photo’s time stamp documented when each seedling emerged.

“The corn was planted on May 16 and the first seedling came up at 11:37 am on May 21. The second, third, and fourth came up from 1.29 to 1.42 days later, while the fifth came up 2.83 days after the first. The remaining seedlings came up 5.75 to 9.83 days later while one never emerged,” says Bob.



2



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- 1 Oklahoma farmer Brent Rendel used time-lapse photography to monitor his canola crop during an overnight freeze.
- 2 Solar powered landscape lights provided enough illumination for the crop.
- 3 A thermometer was visible in nighttime images thanks to the lighting.

“Everybody knows uniform emergence is important, but our data showed there was an amazing impact. Our camera followed the plants through the season and we weighed the ears from each one. Based on our population, the first plant to emerge had a yield equivalent to 203 bushels per acre, the second 179 bushels, the third 163 bushels and the fourth 144 bushels.”

The fifth plant to emerge in Bob’s study had an ear weight less than half the weight of ears from the first two and equated to a 98-bushel yield.

The yield of seedlings 6 to 10 equated to 33, 13, 0, 31, and 0 bushels per acre respectively.

“Crop scientists say corn seedlings that emerge more than 48 hours after their neighbors do little or nothing to help the yield, and this time-lapse photography helped prove it again,” says Bob.

Time-lapse crop photography is helping Iowa agronomist Neil Sass convince skeptical farmers in his area to adopt practices like cover cropping.

“We do a lot of field days on the benefits of cover crops, but many farmers are scared to plant soybeans into a tall stand of cover-crop rye. With the help of local farmer Jacob Groth, we got a 30-second video that shows the soybeans emerging through the thick mat of residue. It makes a great teaching tool,” says Neil.

Both Neil and Bob Recker used standard trail cameras. “Be sure the camera you select has a setting to take pictures at a given interval, rather than just when it senses motion,” says Bob. Trail and game cameras are rugged, weatherproof models designed for extended and unmanned use outdoors.

Battery life varies widely for game cameras. A recent test by trailcampro.com found it ranged from a few months to more than 20 months while taking two to three pictures per hour.

Brent Rendel used a Brinno camera dedicated to time-lapse photography. “It provides a better product than a trail camera, battery life is longer, and it’s inexpensive (less than \$200),” he says.

Most video cameras and even cell phones can be used for time-lapse photos. “There are many free software tools and apps to edit time-lapse pictures into videos,” says Bob. ■



1

Lending land to lend a hand

A pilot refugee program in western Victoria is helping African Australians establish a rural home in their new country.

By Nathan Dyer

Standing in a corn crop on the outskirts of Coleraine in western Victoria, Leonard Nyandwi is smiling. It's been a drier than average summer and the crop hasn't reached its potential, but Leonard is still happy. This corn represents more than food. It's a new beginning. A new home. And a connection to his rural African roots.

"My dad grew bananas and we had a big farm of bananas, and my mum grew cassava and peanuts, and also rice," explains Leonard, looking over the rolling hills of Victoria's Western District, 330 kilometres west of Melbourne, and reflecting on a childhood spent on the other side of the world.

Standing beside Leonard is John Kane, a fourth generation beef farmer who two years ago made the decision to lend Leonard and his family an acre of his land, indefinitely, to grow their own crops.

"I got a call from the Southern Grampians Shire Council asking if we'd host a busload of potential African families who

might want to relocate to the shire," recalls John, who's also president of the Coleraine and District Development Association. "We were going to meet in town, but then I thought if they're from rural backgrounds and they're interested in coming to a country place in Victoria, why don't we meet on the farm."

With a busload of adults chatting on his veranda and children playing on the front lawn, John had an idea. "They were just sensational people and I got thinking – I've got a very strong Irish heritage and we were immigrants to Australia and here was a busload of immigrants, so I started wondering, 'How can I help these people?'"

Fifteen minutes later John hatched a plan. "I decided if they came to the shire I would let them have the use of one acre of my land for an indefinite period," he says, grinning at Leonard. "So that's how I got involved."

The unlikely farming partnership is part of the Great South

Coast Economic Migration Project (GSCEMP), a community led scheme aimed at stemming regional population decline in western Victoria and filling localised skill shortages, particularly in agriculture.

Project manager Lilja Sigurpals, who provides support to families relocating to the area, says the GSCEMP is modelled on a similar scheme in Mingoola on the NSW/Queensland border.

“Our program works with African families from rural backgrounds who have lived in Australia for more than five years and who have registered with our partner organisation the Great Lakes Agency for Peace and Development International, who support their resettlement via the project,” Lilja explains.

“When migrants come to Australia they are generally settled in cities, but their background is rural life, wide open spaces, and we’ve got plenty of that on offer,” explains Lilja. “And there are skills shortages and employment opportunities in regional Australia which these families can help to fill.” Along with jobs, the project supports families with links to housing, schools, service clubs and community groups.

PLANS TO EXPAND

Since the project launched two years ago seven families have relocated to Hamilton and four to Casterton, and there are plans to expand the program across western Victoria.

“Regional living is the lifestyle they want for their families,” says Lilja “Our communities are friendly and welcoming, you walk down the street and you get a smile and a ‘G’day’, and people genuinely want to get to know you,” she says.

Across the region, Lilja says the community reaction has been amazing. “People have embraced the project and the new families and they want to understand each person’s story and background,” she says.

While adults have gained jobs in agriculture, aged care, community services, manufacturing and forestry, Lilja says children are also boosting numbers in schools and sporting clubs.

“At one primary school, for example, eight children have enrolled, which for a small school has increased their numbers substantially” she says. “And the families bring so much to the community, they want to actively contribute to their new home, plus there’s an educational aspect for everyone in encouraging diversity and breaking down stereotypes.”

Having fled war in the Democratic Republic of Congo in 1996, aged 14, Leonard explains how he spent 14 years in a Tanzanian refugee camp before finally being resettled in Australia in 2010. After spending

» This is a nice place where we can raise our children in the countryside, and have a future. « Leonard Nyandwi

almost 10 years in Melbourne, Leonard says the GSCEMP program is giving he and wife Fredina a chance to raise their five children in an environment that reflects their own rural African heritage.

A SENSE OF BELONGING

Leonard, who along with another family has so far grown corn, beans, tomatoes and potatoes at Coleraine for food and to share with the community, says after almost a decade in Australia his family finally feels like it is home. “Because when you come from a background like mine, you feel a sense of belonging when you have land,” he says. “But when you don’t have land, you don’t feel that sense of belonging in the community.”

John Kane says the benefits of the program are obvious. “For years, the biggest export from Coleraine has probably been our young people,” he says, looking over land his family has farmed for 160 years. “These African families have large families, so the impact on the schools and sporting facilities, and other aspects of life in the shire in general is just fantastic.”

A strong advocate for regional growth, John says it makes sense for migrant families to consider relocating to the bush. “You just can’t have Melbourne and Sydney developing at the

same rate as they are at the moment, it’s unsustainable, so we need people to come out to our regional centres,” he says.

Based on his own experience, John says the benefits go both ways. “I’m meeting fantastic people, I know they appreciate it, the kids are so well mannered, everything about the program is just fantastic,” he says. “And to help in some small way is an absolute pleasure.” ■

Footnote: The Great South Coast Economic Migration Project is a partnership between the Great Lakes Agency for Peace and Development International (GLAPD Int.), Leadership Great South Coast (LGSC) and iGen Foundation, with Southern Grampians Shire Council and Glenelg Shire Council.

The program aims to relocate 20 families to the Southern Grampians and Glenelg Shires by the end of 2019.



2

- 1 Leonard Nyandwi and John Kane check the crop.
- 2 Lilja Sigurpals provides support to relocating families.

AGRICULTURE & RESEARCH



ASTRONAUT FOOD FOR COWS

A study published in the magazine *Environmental Science & Technology* projects that industrially-bred and dried microbes could make up almost a fifth of the world's concentrated feed requirements. The technology was originally developed for space travel. At that time, carbon and nitrogen fertilisers were used to propagate protein-rich bacteria, fungi or algae. The study investigated five modern methods of microbial protein production. The use of natural gas or hydrogen, combined with an energy source, for example, would make it possible to completely de-couple feed production from cultivating cropland. Up to 13 percent of the world's forage plant areas could be re-purposed. Other methods use photosynthesis to refine sugar or biogas to protein without the use of external energy, but lead to fewer benefits for the environment. According to the co-author, Dr Isabelle Weindl of the Potsdam Institute for Climate Impact Research, feeding microbial protein would not impair animal productivity and could even have a positive effect on animal growth. The procedure would have the potential to reduce global agricultural greenhouse gas emissions and nitrogen losses. ■



TOGETHER AGAINST HERBICIDE RESISTANCE

With the help of computer simulations a team of researchers from the University of Illinois (USA) was able to demonstrate that co-operative weed management is a good method to curb the development of herbicide resistance, allowing several farms to co-ordinate their individual weed control. The computers analysed agricultural data over the past 30 years in order to forecast the future resistance development of waterhemp until 2050 on the land of 10 adjoining farms. The researchers simulated several scenarios. Where the use of a herbicide was distributed over several farms in terms of time and space, the selection pressure decreased the most. The more farms working together, and the larger area covered, the later resistance occurred. "Farmers are looking for new tools [against herbicide resistance]," says Dr Adam Davis from the University of Illinois. "This tool is free. It only requires that people talk and work together." But such co-operation is often difficult to bring about. Therefore, the study recommends that crop protection strategies be developed in work groups integrated in or based on other co-operations such as marketing groups or co-operatives. ■



GRAPES MUST BREATHE

Australian researchers from the University of Adelaide have discovered that grapes suffocate when deprived of oxygen. As early as 2008, scientists identified a cell death phenomenon that impaired the maturation process of the fruit. With the help of miniature oxygen measuring probes and X-ray computed tomography, researchers have now been able to prove a connection between oxygen content in the grape and cell death. The measurements showed that the latter was more prevalent at higher temperatures. In a comparison between Chardonnay, Shiraz and Ruby seedless grapes it turned out that different grape varieties react differently in a stressful environment. The difference lies in the pores found on the surface of the berry stems which provide the grapes with oxygen via air canals. Shiraz, for example, has fewer pores and spoils faster. "This breakthrough will provide the basis for further research into berry quality and cultivar selection for adapting viticulture to a warming climate," says Professor Vladimir Jiranek of Adelaide University. One possible approach would be to increase the concentration of oxygen pores in more sensitive varieties. ■



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Farming straight up

With vertical farming, the future of horticulture is changing.

By Joe Link

1

Inside a nondescript warehouse in Cincinnati in the United States – a building that once stored barrels of ink – tomato plants rise toward the lights above. The tomatoes are more than three metres tall, narrow and slender, needing to be tied to and interwoven with the strings that stretch floor to ceiling. And, they are loaded with cherry tomatoes. These plants will live and produce fruit for as long as 12 months.

The light in the room is eerie, a spectrum of blue and red that, to the eye, is nothing resembling sunlight – but such is the world of vertical farming.

It's a new era in agriculture – no soil, no sunlight, growing vegetables with roots in nutrient rich water, and perhaps most importantly, they are grown in the community where the crops will be eaten. It is some of the highest tech farming you'll find.

This is one of the farms run by 80 Acres Farms (80acresfarms.com), a firm started three years ago and is growing rapidly – but growing carefully. The Cincinnati location is just one of its farms. With a growing space of 1,000 square metres, the facility here can grow what normally would take 80 acres (32 hectares) – the inspiration for the name. The company has other farms in Alabama, North Carolina, and Arkansas.

VERTICAL TAKEOFF

Hydroponics, growing plants with no soil, is not new, but advances in technology have led to a booming change in this form of agriculture. Vertical farming, known as Controlled Environment Agriculture, is seeing a rapid surge with vertical farms popping up all over the world.

» The growing demand for organic, fresh produce, is giving entrepreneurs incentive to try this new style of farming «

AeroFarms in Newark, New Jersey, claims to have the world's largest, with 6,500 square metres holding high layers of trays of plants. The company claims it can be 390 times more productive than in a conventional farm field.

Why the sudden growth? "The technology has improved drastically," says 80 Acres Farms co-founder and CEO Mike Zelkind. He believes the trend is firmly set for this industry to rapidly grow further.

"Today we have the capability to do this very differently and grow very high quality, very nutritious, densely packed produce right where the consumer bases are."

The biggest change is in LED lighting, bright bulbs that are highly efficient at producing light, emit no heat, and have dropped dramatically in price over the past five years. That, and the growing demand for organic, fresh produce, is giving entrepreneurs incentive to try this style of farming, even though setup costs are extraordinarily high.

The demand for fresh vegetables is what Mike says makes the timing right for vertical farming. "The more delicate items like culinary herbs and leafy greens – things that don't need to be shipped from California 3,000 kilometres away," he says. "Stuff that comes from California, by the time you harvest,



- 1 Rob Norris sets out trays of seedlings to grow under LED lights. In the room are a wide variety of seedlings, mostly lettuces.
- 2 Farmhand Carly Holthaus uses a magnifier to inspect the root system of a basil plant. 80 Acres Farms uses a nutrient rich water, but what isn't used by the plants is filtered and recycled.
- 3 Tisha Livingston and Mike Zelkind, co-founders of 80 Acres Farms, have vast experience in the food industry, previously working with farmers and handling food marketing for large corporations.

process, and ship it, the produce has a couple of days of shelf life and usually it's disappointing.

80 Acres Farms also grows lettuces, kale, and herbs such as basil – lots and lots of basil. Coming soon are strawberries and grapes. "I think you can grow anything," says co-founder and president Tisha Livingston. "But some things aren't going to make sense financially."

Broadacre row crop farmers, for instance, have nothing to worry about; 80 Acres Farms isn't in competition with them. "I don't think anyone's going to be competing with the soybean farmer," says Mike. "Indoor farming is not going to solve world hunger tomorrow. It's not intended to."

Despite the reduced prices for LED lighting, this is still not an easy way to begin farming. The costs to start up are

enormous, and the method is not without its critics. Despite the increased efficiency of LED lighting and the reduced acreage requirements, the carbon footprint remains high.

But the freshness of the produce – harvested one morning, eaten locally that afternoon – is a huge marketing advantage. And there are environmental advantages. The plants are grown with 97 percent less water than field-grown crops. No pesticides are used. There is no runoff as all the water and nutrients are recycled, filtered, then used again.

"We don't believe any single company will be the sole winner," says Mike. "We think there's going to be lots of companies that will eventually be successful doing this." Where he and Tisha believe they have an edge is that they understand the food business, both having years of experience in the food industry and in understanding food markets.

ROBOTS THE NEXT STEP

The company has just broken ground on another farm, 40 minutes away in Hamilton, Ohio, and it will have an even newer twist. Most of the work – the planting, the harvesting, the packaging – will be done by robotics.

For years, futurists have been saying this day was coming. Do a Google search for vertical farming and you're bound to find some illustrations of futurists' visions: space-age skyscrapers that grow food. We're not there, but who knows what the future holds?

The sky just might be the limit. ■

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Out bush

Photographer NATHAN DYER takes us on a journey across the paddocks and plains of rural and remote Australia.

With a focus on rural industries and agribusiness, Victoria-based photographer Nathan Dyer gets rare access to properties across the country.

In this photo essay, Nathan takes *The Furrow* readers on a journey beyond the boundary fences of some of Australia's most iconic properties.

From the Kimberley's oldest cattle station to one of Victoria's largest Merino studs, Nathan's images beautifully showcase Australian agriculture from ground-level and above.

"I consider it a real privilege to visit these properties and it's always inspiring to hear the stories of the people who live and work on them," Nathan says.

"As a photographer, I'm always grateful for how people let me into their lives. Whether it's in Victoria's Western District or one of the vast stations of northern Australia, the people who call these places home all share such an incredible passion and enthusiasm for the industry, and that's a very special thing to see." ■



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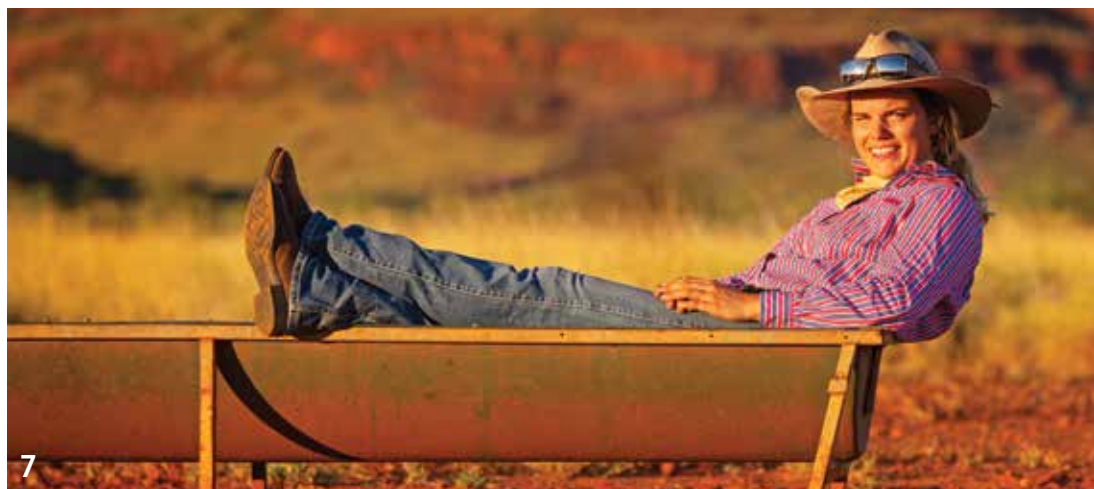


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- 1 Pilbara landscape, Yarrie Station, WA.
- 2 Sunrise on Nappa Merrie Station, Qld.
- 3 Taking a dip in the family pool, Fossil Downs Station, Kimberley, WA.
- 4 Mustering, Fossil Downs, WA
- 5 Nappa Merrie homestead on the Copper Creek, Qld.
- 6 Galahs at Minderoo Station, Pilbara, WA.
- 7 Jillaroo Lydia Inglis takes it easy, Yarrie, WA.



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- 8 The Milky Way viewed from, Iffley Station, in the the Gulf of Carpentaria, Qld.
- 9 Dollar boots, Iffley, Qld.
- 10 Mustering, Fossil Downs, WA.
- 11 Heading out to muster – take off, Iffley, Qld.
- 12 Rounding up the tail, Nappa Merrie, QLD
- 13 Taking a break, Hugh Smith, Iffley, Qld.
- 14 The leap, Wurrook Merino Stud, Western District, Vic.
- 15 Catching horses, Nappa Merrie, Qld.



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- 16 Ringer Colleen Punch, Nappa Merrie, Qld.
- 17 Galahs on the wing, Yarrie, WA.
- 18 Sunset horns, Iffley, Qld.
- 19 Yarding the flock, Wurrook, Vic.
- 20 In the yards, Iffley, Qld.
- 21 Superfine fleece, Wurrook, Vic.
- 22 Sunset ringer, Fossil Downs, WA.
- 23 Mustering, Wurrook, Vic.
- 24 Fitzroy River, Fossil Downs, WA.



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Massive worm farm gets a wriggle on

Feeding four billion head of livestock isn't easy, but it solves some major environmental problems.

By Richard Bentley

Max Morley has worms – four billion of them give or take a few – but they are not a problem. In fact they are helping to resolve some major industrial waste concerns in a sustainable and environment enhancing way.

Max is the chair of Noke Ltd, a New Zealand company that specialises in large-scale composting of organic waste streams using tiger worms. Vermicomposting – also known as worm farming – is hardly a new idea but what is new is the technology and know-how to harness worm power on an industrial scale.

Treated well, worms will transform huge quantities of toxic or problematic organic wastes into vermicompost that enriches soils and boosts crop yields.

Just over a decade ago, small laboratory trials established that NZ tiger worm species could handle waste products from pulp and paper plants and dairy factories. Today, Noke Ltd

» Vermicomposting offers a golden opportunity to return carbon and other nutrients, which would otherwise go to landfill, back to soils safely. «

has seven large sites in New Zealand's North Island, which process around 250,000 tonnes of waste annually from a variety of industries. Its success is all to do with scalability, says Max, and the key has been developing a blend of feedstocks that worms thrive on so that they will be very active and breed rapidly.

“Our job is to create a ‘party’ for the worms where they



have an abundance of food that they like. Worms will bypass some feedstocks and get stuck into others, so we try to sweeten the mix of carbon-rich material with nitrogenous wastes so that it appeals to the worms," he says.

"They are ferocious breeders and if you feed them well and shelter them from the elements and predators they will continue to eat and breed. Worm numbers will increase exponentially."

FAST BREEDERS

A healthy worm will lay a seed pod every day from early spring to mid autumn. Within 14 days that seed pod will give birth to 5 to 7 small worms, and two months later they will be mature enough to breed. However, although the number of worms doubles every two months it took quite a long time for the company to build up sufficient numbers to handle the 900 tonnes of waste that it may now receive on any one day.

Worm breeding started in earnest in 2007 at the instigation of Dr Michael Quintern, a German soil scientist with a global reputation. He was brought to New Zealand by the forestry research organisation Scion and subsequently became the coordinator of the Land Treatment Collective, a group charged with finding a more suitable home for organic wastes.

He identified that every year several million tonnes of industrial wastes from agriculture, horticulture and forestry were going directly to landfill. He was convinced that vermicomposting offered a golden opportunity to return that carbon and other nutrients back to soils safely. In 2009 he founded Noke Ltd in New Zealand to establish this commercially viable upcycling technology.

The primary source of carbon for the project was waste

- 1 Worms breed rapidly on a diet of wood pulp and biosolids, converting noxious wastes into valuable vermicompost.
- 2 Riverland Fruit Company, near Gisborne on New Zealand's north island, uses vermicast and has seen notable improvements in soil structure.

from pulp and paper factories. Their effluent contains quantities of fine, hair-like fibres that are settled out and dewatered to form a clay-like sludge. This material can be handled by front-end loaders and trucked to remote processing sites.

"The fibre gave us a concentrated form of carbon. We then looked for sources of high-nutrient material to blend with it to give the carbon/nitrogen ratio that would support vermicomposting," says Max.

"Trials helped us identify the ideal mix and we started building up worm numbers and capacity. This year we will handle the best part of 100,000 tonnes of pulp and paper waste at seven operating sites, mainly in the central regions of the North Island."

A SIMPLE OPERATION

A visitor to one of those sites might expect to see large buildings and plenty of machinery, but this is not the case. Vermicomposting takes place on open ground and requires little capital equipment.

The company's operation near Taupo illustrates this well. A large stockpile of pulp and paper fibre sits alongside a smaller quantity of nutrient-rich biosolids from the Taupo District Council's sewage treatment plant.

A standard mixing wagon is used to blend the two wastes in the ideal proportions and the mix is taken out by trailer and formed into windrows. Typically these are about 20 metres wide, 1.5 metres high and perhaps 400 metres long. The initial windrow is then seeded with tiger worms.

“Based on the feedstock mix we select the best species of worm from the six available in New Zealand. Within each windrow we effectively have three types – the scavengers that like to live at the top of the mound, then the transitional worms that will also digest and pull that organic matter down to a depth of 15 to 20 cm. They are very good at transporting the wastes down to the main feeder root zone of plants,” says Max.

“Then there are the really important deep-dwelling worms that live in burrows that will go down anywhere up to a metre, sometimes deeper. They go up and down through that burrow as they scavenge for food, which they pull deep into the soil, and the significance is that they encourage the tap root of the plant to establish deep in the soil.”

The advantage of this is that it gives plants’ feeder roots access to water and nutrients located further down in the soil profile. It means greater resilience in times of drought and the absorption of nutrients that would otherwise leach into waterways.

Once the worms get going they take about eight months to convert all the material into vermicast. During that time the windrow needs little attention except for mechanical weed control.



Also during that time another windrow will have been established alongside the first, and when the worms have consumed all the nutritive value in the first windrow they simply migrate of their own accord to the new one.

Vermicast material from the processed windrow is then screened to reduce particle size and to separate out weeds and stones. In the case of the Taupo site the material is spread on the Council’s adjacent pastures that are also irrigated with treated sewage effluent. The result is rapid growth of grass which can be harvested and sold.

Being able to convert a noxious waste into soil conditioner is a huge advantage for the Council. Kevin Sears, the Three Waters operations manager for the Council, says that disposal of biosolids has been a difficult ongoing issue.

“We have tried a number of methods but the worm farm is the only long-term sustainable way that allows us to process the material on the land and return it to the land,” he says.

“It avoids the high cost and ground water contamination inherent in other methods and meets our philosophical and cultural objectives.”

DAIRY WASTE AS FERTILISER

Taupo, in the heart of Waikato dairy country, is the smallest of Noke’s plants. It is the largest, possibly the largest in the world and takes solid waste from a dairy factory and blends it with the carbon-rich material to produce vermicast for use on farms, market gardens and orchards.

Riverland Orchards near Gisborne has used such material





as a fertiliser and soil conditioner on their extensive apple, avocado and pear crops. Carl Hamlin, who looks after Riverland’s field operations, says that they have noticed significant changes.

“Vermicast is a great food for earthworms which take it down into the soil where it is available to feeder roots. We have seen notable improvements in soil structure,” he says.

“Even on a non-irrigated section of the orchard we’ve had better tree health and fruit set and less evidence of stress with fruit loading. As a result there have been improvements in crop volume, size and colour.”

TAILOR-MADE SOLUTIONS

Some of those improvements come from Noke’s ability to tailor the content of vermicast to the needs of the crop. Max Morley says that experiments have shown that a slightly higher calcium content increases fruit setting in apples.

“Some crops may require more nitrogen at a certain point in their production, others may have a need for phosphate or calcium. We work with our customers to understand their specific requirements and offer them a natural solution in the concentrations that they need,” he says.

“We also have different classifications of worm castings, and we were privileged to be the first certified organic vermicomposting company globally handling wood pulp. Through careful blending we can produce vermicast to specification for particular applications.”

Demand for the company’s know-how has taken off, as has the interest from industries and municipalities wanting to find effective land-based solutions to deal with their organic wastes. Noke is working to establish new sites in Gisborne, Napier and Queenstown in New Zealand, and in Queensland, California and Northern Europe.

3 Operations manager Dan Smith checks a mound of finished vermicompost ready for agricultural use.

4 Fine, hair-like waste from the pulp and paper industry – now a rich source of carbon for producing vermicompost rather than going to landfill.

5 A typical mature tiger worm.

6 Finished and screened vermicompost ready for use as a soil conditioner.

7 Vermicast applied onto the soil sample on the right has resulted in better porosity, friability and colour. Earthworms have digested the material and taken it down into the soil profile.

Concurrently, interest in bulk supplies of their final products is growing amongst orchardists, market gardeners, and pastoral farmers using “biological” methods. Noke is now looking to meet the demand for smaller quantities with 1 tonne bags as well as 17 litre and 10 litre bags for the consumer market.

PELLETS, SPRAY IN THE PIPELINE

“We are also doing some interesting work on turning the vermicast into pellets or extruded material that can be applied by fixed wing aircraft or helicopter on land that’s inaccessible to normal spreading methods,” says Max.

“Another trial involves a foliar spray made from completed vermicast, which puts nutrient directly onto the leaf as well as some on the ground.

“The development of this technology has established New Zealand as a world leader in industrial vermiculture. Interest in the intellectual property from overseas will undoubtedly grow, and it will help New Zealand maintain its clean, green status.” ■



Farming without rain

Producing high-protein microalgae is really pushing the boundaries of desert agriculture.

By Anni Fordham

Rainfall can make or break a farming business. Too little rainfall and you're struggling with drought. Too much can cause crop damage or even flooding. But what if we weren't at the mercy of rain? What if we developed ways to thrive whether water fell from the sky or not?

Erin Pope grew up on a family farm near Moorine Rock in Western Australia's Eastern Wheatbelt. Running a broadacre mixed cropping and livestock enterprise in a low rainfall region of Western Australia has its share of challenges, and for Erin, those challenges kickstarted a keen interest in dryland farming systems.

After graduating from university with a Bachelor of Agribusiness, she wanted to learn more about innovations that could help her own family and others in the region get more from their land.

LOOKING ABROAD

In September last year, Erin embarked on a research internship in Israel, a country renowned as a leader in effective water use and desert agriculture.

"I've always been curious to explore farming systems in different parts of the world to see what components help build resilience and enable farming to exist even in challenging environments," Erin says. "I wanted to see what agriculture looks like in a place where it doesn't rain."

The internship, supported by the Jewish National Fund of

» Israel's Arava Desert receives less than 30 mm of rainfall annually, yet produces more than half of the nation's fresh produce for export. «

Australia and the Finkel Family, focused on desert microalgae research with the Arava Research and Development Centre.

Erin spent six months living in a moshav (farming community) in the Arava Desert, which receives less than 30 mm of rainfall annually, yet produces more than half of Israel's fresh produce for export.

During her time in the Arava, Erin assisted with research into desert microalgae production and got hands-on experience in the cultivation of spirulina, which is produced commercially as a high-protein animal feed source and health food additive.

While there are a few companies involved in industrial scale production of microalgae in the Arava, the research centre wanted to explore the possibility of spirulina cultivation at a farmer level, bringing more diversity into the farming region.

"Algae was something I had never thought of as a farming system before, let alone an option in dryland or desert areas," says Erin. "It has a small environmental footprint and the



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- 1 The greenhouses of the moshav farming community in one of the world's driest areas, looking towards the mountains of Jordan near the Israeli border.
- 2 The Arava Valley is full of greenhouses growing tomatoes with drip irrigation for export to Europe.

biggest advantage is that it can be produced in areas that do not compete with existing farming industries."

Algae cultivation is not the first thing that springs to mind when thinking about WA's Wheatbelt, but there are definite parallels.

"There are many shared challenges between farmers in the Arava and the Eastern Wheatbelt," Erin says. "Both are trying to run profitable farming businesses while negotiating their way around salinity, heat stress, cold stress and poor soil quality. While the farming systems are very different, there is a lot to learn from Israel in terms of their effective water use."

COULD MICROALGAE BE THE ANSWER?

Although it might sound unusual, the concept of microalgae production is not completely new to the Wheatbelt. In 2016, the Shire of Merredin expressed an intention to develop a business case for the development of a local spirulina production venture, but the plan was shelved due to a lack of funding support.

Chief executive officer Greg Powell says the spirulina project was the Shire's attempt to address declines in both population and rainfall.

"Population decline in the Wheatbelt is a big issue," Greg says. "The Merredin region has become drier in recent years with winter rainfall less reliable, so diversification is something that the Shire is keen to explore. Diversifying the

region's economic base would also mean that the region is not solely reliant on just cropping and livestock as its two main sources of income."

Greg says while the Shire itself is not looking to pursue the spirulina project, it would welcome interest from the private sector.

A keen traveller, Erin is driven by a desire to understand how different communities are overcoming their challenges and says there's plenty more to learn from the Arava.

SHIFTING THE BOUNDARIES

"I'm drawn towards remote, dry landscapes because there's a sense of shared experience with the people there; a sense of capability and resilience," she says.

"In Israel, they're growing vegetables on land not ideal for agriculture, using a slightly saline water source, and producing vegetables of a high enough quality to export internationally.

This has shifted the boundaries of what I thought was possible for dryland farming systems and made me think



about how we can turn challenges around and use them to our advantage.”

Erin was struck by the Arava farmers’ inclination to forgo traditional farming techniques in favour of innovative solutions.

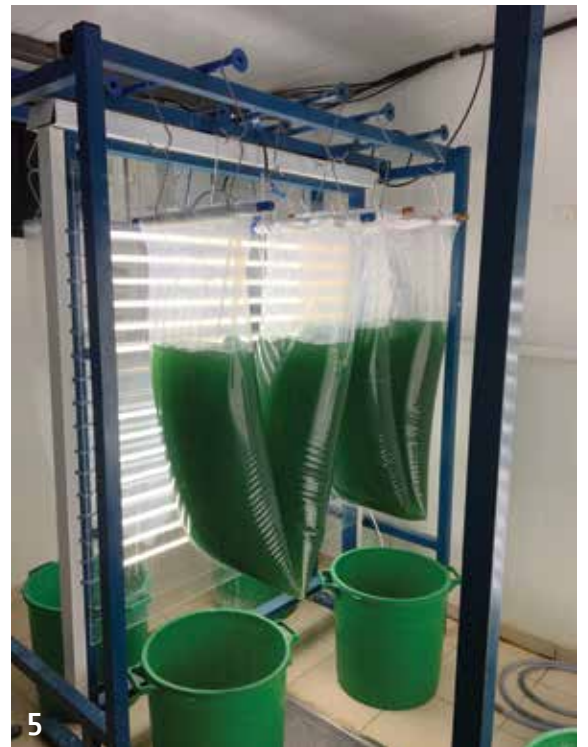
“Because farming in the Arava region is still relatively new, there is not this mindset of ‘we will do what we did in the past’. There’s not as much of a generational passing down of knowledge, so they are perhaps more willing to try different things, resulting in quite a dynamic environment.”

Growing up on the family farm, Erin has seen plenty of good and bad seasons, and has witnessed first-hand the

- 3 Date palms complement the production of greenhouses on the Arava moshav.
- 4 Erin Pope inspects a 50,000 litre raceway of spirulina before harvesting.
- 5 Building up the spirulina culture under controlled conditions of light intensity and temperature.

effects of climate change on rural communities.

“Just as the people of the Arava are being pushed to adapt and create new ways to survive, we in the Wheatbelt are facing the same challenge. This is where innovation happens.” ■





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Hemp offers a healthy alternative

Industrial hemp may be about to join the cropping rotations of more farmers, offering agronomic benefits as well as potential in the high-value health food market.

By Liz Harfull



When Jack Altschwager heard that the South Australian agriculture department was looking for farmers to grow the State's first commercial-scale crops of industrial hemp for human consumption, he was quick to get in touch.

The Limestone Coast farmer and his father Greg have had plenty of experience growing cereal, oilseeds and legumes on highly productive grey loam flats at their Tantanoora property, near Millicent. So they already had the equipment to sow, irrigate and harvest the short-term summer crop, making it a practical and relatively low-risk option.

Industrial hemp also had considerable appeal because of its reputed benefits in the cropping rotation, boosting organic matter in the soil and opening the ground up because of its deep-growing tap root. Then there was encouraging predictions of rapidly expanding markets for high-value health food products made from the seed and oil. "I thought we should give it a crack," says Jack.

FIRST SEEDS WITH THE FIRST FLEET

The Altschwagers were among a rapidly growing number of Australian farmers who this past summer grew industrial hemp for the first time, following a change in national laws in late 2017, making it legal for human consumption. But hemp is not a new crop, even in Australia.

Famous British botanist Sir Joseph Banks reputedly sent out seeds with the First Fleet in 1788, so the colony could produce fibre for manufacturing items such as sails, rope and twine.

1 Greg Altschwager dwarfed by a plot of the multi-purpose Chinese hemp variety, Han-NE, grown for both fibre and seed, at the South Australian Research and Development Institute trial site.

» Hemp is an indeterminate plant, so the first lot of seed can be dry and the plant can still be flowering. Getting the harvest timing right is a huge challenge.

« Jack Altschwager

Success growing hemp in Victoria in the late 1800s received widespread media coverage, with the *Millicent Times* publishing agronomic advice for interested farmers. The Agricultural Bureau branch that Jack and Greg belong to even received an encouraging letter in 1896, explaining that it was a dioecious species, which means that male and female flowers develop on separate plants.

Then in the 1940s, Australia followed America's lead and made importing and growing hemp, or cannabis, illegal because of escalating concerns about it being used as a 'sex drug'.

Because of its capacity to produce large quantities of valuable fibre, countries like Canada revisited the crop in the 1990s, focussing on 'harmless' varieties with very low levels of the mind-altering ingredient, tetrahydrocannabinol (THC).

Australia explored the opportunity too and some states allowed it to be grown under strict licence, as long as it was not sold for human consumption. However, by 2011-12 estimated national plantings amounted to only 185 hectares, worth an estimated gross value of just \$300,000.

After years of lobbying, the introduction of the new laws in 2017 changed everything. Jack and Greg were among about 240 people from across Australia and overseas who gathered



in Geelong in February last year for the first Australian Industrial Hemp Conference to learn more about the practicalities and the market opportunities.

They discovered that Canada, Europe and China already had substantial industries. A speaker from Canada told delegates that their country's hemp industry was growing by as much as 30 percent annually, with projections it would be worth \$1 billion by 2023.

A GROWING WORLD MARKET

Hemp seed, oil, flour and protein were highly sought after by the health food market as sources of Omega 3 and 6, high levels of protein (20 to 30 percent), and essential vitamins and minerals. Products using hemp seeds could already be found on supermarket shelves across Australia, and there was growing worldwide demand too for the fibre to make clothing, building materials and paper.

Heartened by what they had heard, Jack and Greg applied for the State government licence and police check required for the highly-regulated crop. After considerable effort because of supply pressures, they managed to obtain 300 kilograms of a French variety, Felina 2, from Good Country Hemp, which is establishing a processing plant at Bordertown.

In mid November, the Altschwagers sowed an 11-hectare paddock that was coming out of lucerne and chicory pasture after eight years. "It was pretty clumpy so we went in with the discs first. We worked on it until we had a really fine seed bed, maybe three or four passes, then we rolled it," Jack explains.

A sowing rate of 30 kg/ha was recommended, but it worked out more like 27 kg when they decided they might as well cover the whole paddock. "The aim was to end up with 75 plants per square metre, but we got a higher germination and survival rate than expected so the sowing rate still turned out to be way too heavy," says Greg.

Like most of the farm, the paddock had free-draining grey loamy soil, with a high pH of about 7.8 and high calcium levels. "It's a major issue because it locks up trace elements, so we use a lot of foliar sprays on all our crops, and very little hard fertiliser," Greg says.

After doing some online research, 100 kg/ha each of monoammonium phosphate (MAP) and urea was broadcast at sowing, to meet the crop's high demand for nitrogen. The crop germinated within about six days. "Then it just sat there, about 10 centimetres out of the ground, for three or four weeks, and didn't move," says Jack.

"I think heat was the biggest issue. After a cold, wet spring we finally got some summer weather and it went ballistic. It grew about 1.5 metres in two weeks."

Early challenges included controlling cut worm and heliothis moths. A few weeks after emerging, the plants also started turning yellow. After doing yet more online research, Jack decided boron deficiency was the most likely culprit and applied a foliar spray. A second dose was required about a week later, followed by a third spray in late December to provide magnesium, copper and zinc.

All but one hectare of the paddock was covered by centre-pivot irrigation. Larger rain events delivered 38 mm during the growing period; the equivalent of another 100 mm was applied by irrigation. "We were told it was going to take 6 megalitres of water to grow, but it's taken a lot less, and the dryland stuff that only received the rain still looked pretty good," says Jack.

While they found growing the plant relatively easy, harvesting had the potential to be a different story. Numerous growers reported difficulties handling the crop in conventional headers because of the long, tough stalks. "If it gets a chance to wrap it will. The recommendation is not to use a twin-rotor machine," Greg says.



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“Hemp is also an indeterminate plant so the first lot of seed can be dry and the plant can still be flowering, so getting the timing right is a huge challenge. We had plants that were dead and others that were extremely green so deciding when to harvest was our biggest issue.

“And the seed needs to be food grade so it has to be dried within four hours of harvest, otherwise it starts to deteriorate. If you had your own drying equipment it would be fine, but we had to deliver it to Good Country Hemp at Bordertown, which is a two-hour drive.”

When it came to yields, the Altschwagers found considerable variation across the paddock, ranging from well below the expected average of about 800 kg/ha to 1.5 t/ha. “Anything above a tonne is good,” Jack says.

DRYLAND POTENTIAL

Depending on how the market develops, Jack is open to growing hemp again. He is keen to try its potential without irrigation, to see if it can be used more widely as part of the property’s existing cropping rotations, which include broad beans, canola and wheat.

He would also like to see a fibre-processing plant established in the region, to expand farmers’ marketing options. “It generates a huge biomass that can be turned into things like paper and building materials. You can grow four times the amount of biomass in one year as a forest plantation takes 30 years to produce,” he says.

According to South Australian Research and Development Institute research scientist Mark Skewes, farmers need to think carefully before taking the crop on, especially if it requires investing in new equipment. “We don’t know if it is viable enough yet because the market is still being established,” he warns.

As manager of the State’s trial program, he has discovered

- 2 Part of the Altschwager’s crop, showing a green head amongst the riper plants, ready for harvest.
- 3 Jack Altschwager in the farm’s first industrial hemp crop.
- 4 Harvesting the crop in late March.

first hand that there are also plenty of agronomic challenges, relating to water quality, weed control, growing seasons and selecting the most suitable varieties to suit local conditions. “Our experience is that it’s a bit more sensitive than other crops, particularly when the plants are emerging and establishing,” Mark says.

A trial in the first year at Kybybolite in the South East struggled because of water-logging and salt burn, leading to recommendations that irrigation water needs to be less than 1,500 parts per million total dissolved salts, or 2,700 electrical conductivity units (EC). Last summer the South East trial was moved to a site with black, crumbly self-mulching soils and better quality water at Maaoupe, near Penola, producing much better outcomes.

Mark has also observed huge variation in the growing habits between different varieties. “Sowing times in our trials vary from late October through to just before Christmas, and some of the varieties are daylight-sensitive. It doesn’t matter how early you plant them, they will wait until the sunlight hours start to shorten before flowering is triggered,” he says.

At another trial site at Loxton, the Riverland’s lighter, sandy soils caused problems when sand drift buried plants as they emerged, resulting in poor survival rates and weeds taking over. “If you can establish a good thick stand, weeds are not a problem. But if you don’t there are no registered post-emergent chemicals available in Australia yet to control them.” ■

Hop to it!

Specialty hop cultivars developed in New Zealand have become brewing household names and a driving factor in the global boom in the popularity of craft beer.

By Kirsty Cooper

The Motueka region at the top of New Zealand's South Island is blessed with ideal conditions for growing hops – the right latitude, good soil, a benign climate, good water supply and few pest or disease pressures.

It's here that scientist Dr Ron Beatson and his team have been working in hop breeding, selection and cultivar development for more than 35 years. And their efforts have found favour with craft brewers around the world.

After the end of World War Two, the New Zealand beer industry was in dire straits. Hop growers were battling to overcome a *Phytophthora* root rot disease, so early research by government agencies and industry was aimed at producing disease-resistant strains of hops. While that was successfully achieved, by the early 1980s hop production in New Zealand was still only a domestic industry. Then problems in international production created opportunities for exports of New Zealand hops to Germany, the United Kingdom, Japan, North America and Australia.

Ron, principal scientist with Plant & Food Research, says the focus from an early stage was to breed seedless cultivars, because seeds contain certain compounds that can release impurities during the brewing process. The challenge has been to create enough genetic variability within a seedless

» Hops offer a spectrum of big strong flavours, aromatics and bitterness, giving brewers the ability to combine them to create unique beers. « *Kerry Templeton*

hop breeding population but these have been overcome by some innovative approaches.

Ron adds the other (good) challenge is, "how to select among all the wonderful seedlings we produce each year". Current breeding targets are aimed at creating new triploid seedless cultivars for the craft and commercial sectors.

The new hop cultivars are not only seedless but have distinctive flavours and about 85 percent of New Zealand's hop cultivar production is exported.

Further impetus to ongoing research was provided in 2013 with the awarding of a six-year grant from the Ministry of Business Innovation and Employment combining with the resources of Plant & Food Research, and New Zealand Hops Ltd, a grower-owned co-operative.





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Ron says the hop breeding and selection programme is a complex and long-term commitment. It's a combination of the research disciplines of genetics, chemistry and brewing trials with the major focus of identifying new selections with unique flavours.

It takes 10 to 15 years from crossing and parental selection through to grower trials. The process begins with individual plants grown in the hop garden at the Motueka site. Each year around 2,000 seedlings are closely monitored by Ron and scientist Kerry Templeton. From these individual plants, approximately 50 high performers are selected and the following year, cuttings are taken to produce five clonal plants of each selection for growing on.

Following a year of field establishment, hops from each of these clonal selections are harvested and processed through

- 1 Hop cones ready for harvest.
- 2 Dr Ron Beatson inspects the clonal selections in the shade house.
- 3 Harvested hop plants tagged and ready for cone removal and drying.
- 4 Bright yellow lupulin glands are found only in female hop cones.

the drying shed, inspected, and weighed for dry matter production. They are then processed in individual batches ready for the micro-brewery.

As part of identifying potential new winners in the commercial arena, trained sensory panel members undertake aroma profiling, using a lexicon of 13 attributes, including those described as "dried fruit, biscuit, baking spices, floral, tropical, citrus, grassy, woody, savoury spices, and sweaty".



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In 2014, a government grant enabled a micro-brewery for research purposes to be built. Known as “The Hop Lab” it was developed in partnership with New Zealand Hops Ltd and Chris Little Engineering.

It allowed the team to create experimental brews from promising new hop selections in order to evaluate their sensory characteristics. The advantage of the pilot plant is that it can complete a brew from a single plant, whereas commercial brewing trials usually need 100 to 200 plants. And, with a particular hop being the only variable in the system, it enables direct comparisons to other selections in the same batch, and the entire selection process to be sped up considerably.

Scientist Kerry Templeton has described his current role at Plant & Food Research as his “dream job”. A plant breeder and craft beer enthusiast, he is about to take over the reins of the hop breeding program from Ron.

STRONG FLAVOURS

Kerry explains that hops offer a spectrum of big strong flavours, aromatics and bitterness, giving brewers the ability to combine them to create unique beers. The program is designed to reduce the guess work out of brewing through analysing the chemistry of the hops, tasting panels and commercial brewer evaluations. Kerry’s ambition is to test over 200 selections of new hops each year.

There are about 500 known compounds that contribute to making the flavours produced by hops. At Plant & Food Research about 100 compounds have been identified and

- 5 The hop garden at Plant & Food Research’s Motueka site.
- 6 Kerry Templeton and Ron Beatson with the latest brew from The Hop Lab.
- 7 Otago University Food Science PhD student Victoria Purdy packs dried hops for further chemical analysis.
- 8 Individual plants are selected for harvest and brewing trials.

measured. The flavour comes from oils produced by the bright yellow lupulin glands of female plants.

The impact of the program has been to incentivise a rapid growth in production and uptake of new cultivars. In the mid-eighties there were around 200 hectares of hops growing in the Nelson region. It took 30 years to increase the planted area by 200 to 400 hectares in 2015.

The growth stimulated by government and industry investment meant the next additional 200 hectares was achieved in only two years. There are currently 22 cultivars of hops grown commercially in New Zealand.

Steve Wilson, finance and commercial manager at the grower owned co-operative New Zealand Hops Ltd says the program has created potential for a long term future for the industry, with another nine hop growers joining the co-operative in the past two seasons.

This new activity is providing job growth as well as further export potential. The planted area for the 2019 crop grown by shareholder suppliers was close to 728 hectares, with other



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companies estimated to have about 80 to 100 hectares in production, and more to come on stream by 2020.

Ron says New Zealand currently produces less than 1 percent of the world's crop. The industry has a target of doubling that in the next 10 years. Steve Wilson estimates for New Zealand Hops, total production may reach 1,350 tonnes by 2021 which is approaching twice the level of the cooperative's crop size in the previous few years.

CHALLENGES AHEAD

He adds the 2019 crop harvest is in progress, with some tough climatic conditions impacting what the final yield results might be. He cautions however, that in the future, challenges may arise in growers maintaining sustainable economic

returns from large investments when the supply/demand equation for any given cultivar will be further tested in a world hop market that is in balance on an overall production basis.

Ron says ongoing investment will be needed from the industry to create more cultivars that can command premium prices. Steve Wilson agrees that the new varieties that have been bred and released in New Zealand have provided a competitive advantage with a product set that is being very well received by discerning brewers worldwide. The New Zealand hop breeding effort has enabled commercial growers to move away from commodity type varieties and markets and refocus on supplying unique and distinctive aroma varieties to the booming craft beer markets. ■



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PRECISION HARVESTING.

**DOES IT HAVE THE INTELLIGENCE TO
MAINTAIN OPTIMAL SETTINGS AS
CONDITIONS CHANGE?**

WILL IT MAXIMISE MY HARVEST PROFITS?

**DOES IT ALLOW ME TO SUPPORT MY
OPERATORS REMOTELY?**





JOHN DEERE



To answer these questions, and more, we got a group of grain farmers together to show them our latest MY19 S700 Combines. We wanted them to experience first-hand how they can maximise productivity and profits through built-in, state-of-the-art intelligence that's simple to use for even inexperienced operators.

See how they got on at JohnDeere.com.au/PrecisionHarvesting or JohnDeere.co.nz/PrecisionHarvesting

PRECISION PAYS

Making the connection

The internet of things comes to the farm.

By Lorne McClinton

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The technology behind Amazon and Google's smart home devices which allow consumers to make toast, lock their door, and start their cars over the internet is starting to revolutionise how farmers manage their operations.

The Internet of Things (IoT) refers to any sensors and devices which have the capability to connect to the internet. Cisco Internet Business Solutions group predicts that there will be 50 billion connected devices by 2020. McKinsey Global Institute projects that it could deliver up to \$11 trillion dollars in economic value by 2025.

In Canada dairy farmers have been among the first to adopt the technology. They're routinely using connected devices to feed and milk their cattle as well as to track individual animals movement and monitor their health. Cash croppers are using them for everything from monitoring growing conditions to controlling irrigation systems. So even though the technology is new, there are endless lists of IoT products available that can enhance a farm's operation.

CHANGING THE CHANNEL

The technology is being adopted rapidly for the same reason that the television remote control caught on so quickly a generation ago – it makes users' lives easier.

Likewise, you could physically go from bin to bin and site to site, to manually check your grain's temperature and moisture levels using a probe or by plugging into the sensor cables. You could turn the aeration fans on or off as needed while you were there.

However, the latest IoT models, like the OPI Blue, allows you to do all this from anywhere in the world with a smartphone or tablet.

Since wireless remote bin storage technology makes

» These days farmers are getting covered in digital hydraulic oil, but I'm certain we'll eventually end up with a standard that everything will work with.

« Rob Saik

monitoring stored grain simple, farmers could check all their bins as often as they like for peace of mind. They can even program them to automatically send text or email alerts if any issues arise. These systems are so new that only a handful of farmers now have them. But if the amount of interest they're attracting at farm shows is any indication, they'll be common in a year or two.

"We don't have any yet," says Jeff Wilkinson of Yellow Grass, Saskatchewan. "But we plan to have some in place for next year. Mostly," he jokes, "So dad will stop texting from Phoenix asking what the bin temperatures are."

Similar devices are now readily available to control the environment in pig, chicken, and dairy sheds too. Fans, sprinklers, or fogger cooling systems are set to activate whenever the temperature rises above a pre-determined limit. They also can be programmed to automatically text or email a designated contact person if anything goes wrong.

Likewise, when one of the 27 milking robots at Ferme Landrynoise, Daniel and Carl Landry's dairy near Saint-Albert, Quebec, breaks down it will automatically call the herdsman on shift to let him know that there is a problem,



Daniel Landry says. “Usually they will be able to troubleshoot and fix what is wrong within 10 minutes.”

The robots have made quantifiable improvements to their farm’s bottom line, Carl says. But perhaps their biggest benefits are in the improvements they’ve made to the brothers’ quality of life.

Until recently, consumers had to use different apps to run all their smart home devices. But the rapid adoption of Amazon’s Echo (Alexa) and Google’s Google Home has forced developers to make their devices compatible. Rob Saik, the founder of Agritrend in Red Deer, Alberta, believes something similar will happen with the smart farm, too.

THE SMART FARM

“Farmers want their devices to work together but it’s hard to get the different platforms to talk to each other,” Rob says. “I believe the same thing will happen with data that happened with hydraulics. At one time every tractor manufacturer had their own hydraulic couplers; we had Pioneer ends, John Deere ends, and Case ends. Any time you moved an implement to a different color tractor you had to either use adapters or get out your crescent wrench and change the ends,” Rob says.

“You were always covered with oil until the companies agreed to use a common system that allowed producers to

1 Canadian dairy farmers routinely using connected devices to feed and milk their cattle.

2 Many companies offer remote sensors that monitor temperatures in livestock sheds. They will send emails or text alerts to a designated person when temperatures rise above a preset level and activate fans, cooling sprinklers, or foggers.

quickly switch back and forth. These days farmers are getting covered in digital hydraulic oil, but I’m certain we’ll eventually end up with a standard that everything will work with.”

While there are amazing smart farm devices on the market today, not all farmers are able to make use of them. The technology requires a reliable fixed and/or mobile broadband internet connection.

While most Canadian farmers have at least one internet service provider (ISP) offering some broadband service to their farms, only the most fortunate have access to the affordable, fast connections that urban businesses take for granted.

“Even if 3G and 4G service is widely available in a region, there are often significant gaps in the coverage,” says Ken Jackson, with Intelliconn Communication Solutions in Saskatoon, Saskatchewan. “It’s going to be even worse once they start to roll out 5G. While adopting 5G provides much



- 3 The Internet of Things lets farmers control irrigation systems with their mobile phones.
- 4 Remote sensor technology lets grain producers monitor their storage bins from anywhere
- 5 Ken Jackson uses radio technology to establish WiFi domes to provide internet coverage across entire farms.

faster internet connections than 4G does, the signal has 25 to 30 percent less range.”

“But there are so many people working on the problem that it’s my assumption that this nut is going to get cracked eventually and broadband internet connections are going to be ubiquitous,” says Rob Saik. “When they do, it opens up a plethora of opportunity because suddenly the cost of monitoring anything is going to go way down. They’ll start to show up everywhere. People will install heat and vibration sensors on bearings to drop their repair costs. Agronomists will use a combination of sensors and drones to monitor fields without having to walk them.”

A lot of the research and development focus is now on using low-power wide-area networks (LPWAN) to support the IoT, says Ken Jackson. The two types that are attracting the most interest are LTE-M (Long Term Evolution Category M1) and LoRa (long range low power).

LTE-M’s biggest advantage is the devices are cheap and it’s

fairly simple for mobile phone companies to tack it on to their existing LTE towers. It’s great for connecting low powered battery-operated devices. One of their great advantages is they have the capacity to go into a sleep mode and only power up for periodic connections.

ENCRYPTED DATA

LoRa networks are significantly more complex. They send packets of information from a node, say a field moisture sensor, up through a gateway and into a cloud network. Their biggest advantage is the data they send is encrypted so it’s a lot more secure.

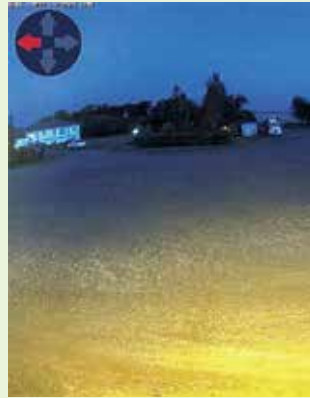
It’s still possible to use IoT technology as long as you have access to a broadband connection on your farm. Ken Jackson’s company uses radio technology to create a WiFi internet mesh or dome that provides seamless internet coverage across a farm.

“We run an ethernet cable from your ISP’s modem to a hub

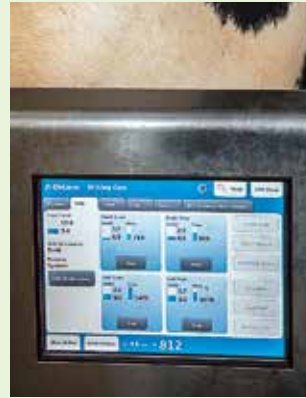
Four ways farmers can make more connections



Visual access. Remote cameras require more internet bandwidth but do provide producers with increased operational visibility of sensitive areas. Motion activation triggers mean they only start recording when something is going on.



Security. Biosecurity is becoming more important all the time as farms grow larger. Driveway sensors and security devices alert you when someone enters the farmyard so you can identify whether it's someone who should be there.



Robotic control. Milking robots have allowed farmers to collect incredibly detailed data on all aspects of any cow's milk production and general health. Producers have access to it from anywhere in the world with a smartphone or tablet.



Activity trackers. There are multiple types of sensors and tracking devices that can be attached to the legs, neck, ears and tails of cattle to allow monitoring of their location, activity levels, health, when they're feeding or in heat, and starting to calve.

that's installed on an antenna or some other high spot outside," Ken explains. "The hub does two things; it creates a wireless dome of coverage that extends about five kilometres across and also creates a WiFi hotspot between 150 and 200 metres in diameter. A second hub can be set up anywhere within the initial five kilometres dome that has line of sight to the first hub. It creates a second hotspot and extends the dome another five kilometres. You can keep adding them to get coverage across the farm."

Each component automatically transfers data from one unit to another in a seamless mesh so the signal isn't encumbered by obstacles in the field, Ken says. However, the data bandwidth is cut in half each time it switches through a hub so the practical coverage limit is a three-hop jump. So that would provide you with a dome that's somewhere between 10 and 15 kilometres in diameter.

PLUG AND PLAY

"Once the mesh is up and operating, WiFi is WiFi," Jackson says. "It's not a proprietary protocol. Once you have this kind of infrastructure set up around your farm you can bring home just about any device you can think of and installation is just plug and play. It even reduces the need to have good mobile reception around your farm since most phones are able to switch to WiFi-based voice calls."

Many farmers want it for cameras, Ken says. Initially people got them to increase their operational visibility but he says most are now buying them for security purposes to know who's coming and going.

Cameras create special problems for data management though. Most IoT devices just send bytes of data, not megabytes – but even small image and video files are very much larger.

Ryan Enns installed a wireless mesh over his dairy farm near Warman, Saskatchewan. He uses WiFi-connected cameras to monitor when cows are calving and keep track of who's coming onto his farm. It also made it possible to have an internet connection in his workshop.

"The workshop connection and the exterior camera worked as we hoped," Ryan says. "But the calving pens were too dark for the cameras to show us what we wanted to know. Now that we have WiFi I think our next step will be to use it to remotely monitor the temperature in our grain bins with sensing cables."

It's still the dawn of the IoT age and farmers are struggling to determine how to integrate these devices into their operations. But all indications are that they will simplify so many common tasks that they will quickly change producers' day to day routine. After all, when was the last time you changed the TV channel without a remote? ■



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