AUSTRALIAN GRAIN

www.ausgrain.com.au
May–June 2020

Australian Grain
PO Box 766, Toowoomba 4350
Deliveries: 2 Kirk St Toowoomba 4350
P: 07 4659 3555
F: 07 4638 4520
E: grain@greenmountpress.com.au
www.ausgrain.com.au

Advertising
Michael Cook
(National Advertising Manager)
P: 07 4659 3555
F: 07 4638 4520
M: 0428 794 801
E: advertising@greenmountpress.com.au

Editor
Lloyd O'Connell
Associate Editor
David Dowling
Production and Design
Mick Allan
Accounts
Deb Meddleton

Published by Berekua Pty. Ltd.,
40 Creek Street, Brisbane
Registered by Australia Post Publication No. PP100002295. ISSN 1449–2970.

Published bi–monthly.
Grain Yearbook published in April
1 year subscription is $60 (incl GST)
(6 bi-monthly issues plus the Grain Yearbook)
2 year subscription is $100 (incl GST)
(12 bi-monthly issues plus the Grain Yearbook)
Ph: 07 4659 3555 to subscribe

FRONT COVER

Harvesting heights

Harvesting of summer crops was a very rare sight around southern Qld in 2020. An even rarer sight is this drone's eye view of a dusk-gathering of header, chaser bin and truck on the Charles' family farm in the Cambooya district. See page 47.

(PHOTO: The image was taken/piloted by 9-year old William Charles).

Contents

Focus Sections

Southern Australia Focus

Covering cropping systems of Southern NSW, Victoria, South Australia, Western Australia and Tasmania

Northern Focus

Covering Northern NSW and Queensland

New chemistry New thinking New Paradigm

with the flexibility that you have always wanted

Paradigm®
Arylex® active

HERBICIDE

Paradigm® Arylex® active Herbicide delivers a low dose, wide spectrum solution for the control of broadleaf weeds.

Widely compatible with the ability to safely go across wheat, barley, oats and triticale. Paradigm fits easily into your spray programme.

Increase your productivity with less downtime due to tank clean out, changing the spray mix or worrying about compatibilities.

Get some precious time back and make life easier.

Shift to the new Paradigm Arylex active.

For more information 1800 700 096

CORTEVA™ agriscience

Visit us at **corteva.com.au**

PAY LESS PAY LATER

THE 2020 SIMPLICITY EARLY ORDER PROGRAM IS RUNNING NOW

Simplicity Australia is offering huge factory discounts on our entire range of Air Seeders. With a tapering discount structure - the earlier you order, the more you save! Best of all, payment is not required until December 2020*. To find out more, visit our website or see your local Simplicity Dealer today.

As an added BONUS, every machine order received under the Early Order Program will receive a Limited Edition Simplicity Australia Leatherman Wave+ Multi-tool.

** Deposit required for placement of order. Conditions apply.*

BONUS

LEATHERMAN
Wave+ Multi-tool

Simplicity
AUSTRALIA

www.simplicityaus.com.au

Editorial... Lloyd O'Connell

BY any measure, the past few months have given all of us a wild ride into the 2020 the winter cropping season. Covid-19 continues to be our invisible enemy, China became a much more tangible barley trading enemy and ex-tropical cyclone Mangga joined forces with a strong cold front and tried her best to re-locate Western Australia to the eastern seaboard.

Despite these challenges sent to regularly test us, generally speaking, the national winter crop is set-up very nicely. Even the Bureau of Meteorology is joining in with some relatively unguarded optimism. In their climate outlook released in late May, the BOM says there is a 75 per cent chance of receiving between 50 and 200 mm between June and August across most of the national grainbelt. And for those areas that might miss out on the really good falls, at least average rainfall can be expected.

In no small degree, we can thank the influence of the Indian Ocean Dipole and generally warmer oceans to the east and west of the continent for this improved seasonal outlook. The IOD is currently neutral but is expected to head into negative (read as good) territory around mid-winter. A negative IOD typically brings above average rainfall to southern Australia during winter and spring.

In addition to the potential for a negative IOD developing, the BOM says that warmer than average temperatures in the eastern Indian Ocean are increasing the likelihood of northwest cloudbands forming during winter and into spring. These cloudbands interact with troughs and fronts and bring rain as they travel eastwards over the continent.

Fanciful and not the facts

The Australian Farm Institute and GrainGrowers have provided an excellent article in this issue (see page 29) which provides some much needed background to the barley tariffs debacle. China wants us to believe that the 80 per cent tariff imposed on Australian barley imports is an "anti-dumping" measure to counter Australian government subsidies and other support apparently given to our producers.

You and I both know this is fanciful BS but the AFI and GrainGrowers have done a great job of presenting the facts; namely, Australian (and NZ) farmers are the least supported in the world. And the most supported? You guessed it – China.

And speaking of facts, our evergreen tractor historian Ian Johnston – in his inimitable style – walks us through the early days of the 'Nebraska Test' and how, a century later, this test has evolved into the foremost independent arbiter of tractor performance in the world (see page 16).

And continuing on this nostalgic note, *Australian Grain* has officially entered its 30th year of publication. From the team at Greenmount, a heartfelt thank-you to our many readers, contributors and advertisers. Together we've survived booms and busts, droughts, bushfires, plagues and pestilence – but we're still here and still enjoying getting high-quality and relevant information to your mailbox. It's been a wild ride!

AUSTRALIAN GRAIN
www.ausgrain.com.au

In this issue...

IF WE'RE EMPTY, SEND US PACKING.

RETURN YOUR EMPTY DRUMS AND SCHÜTZ IBCS TO YOUR RESELLER TO BE RECYCLED.

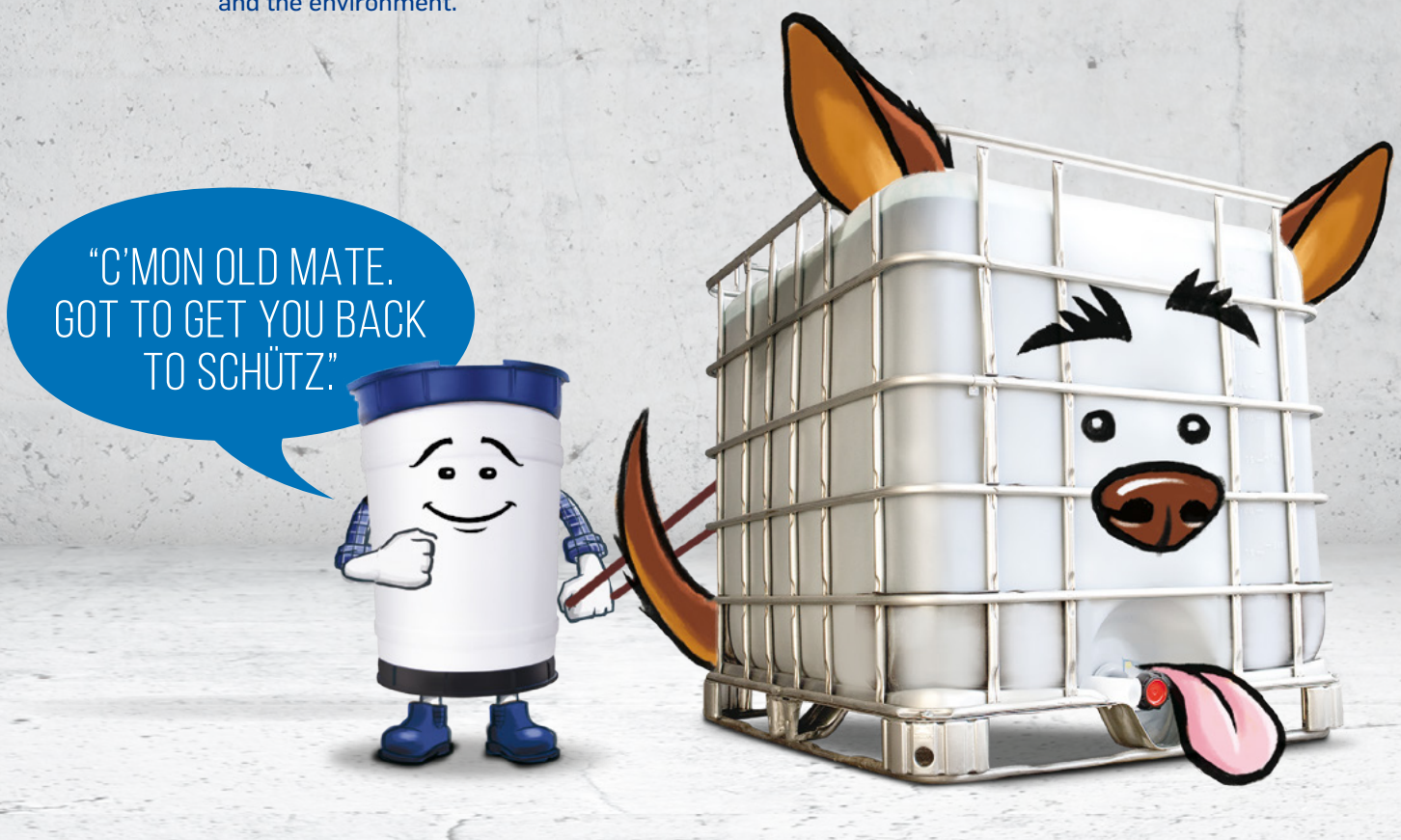
With spring in full swing, there's no better time to clean up the farm and return your empty drums and SCHÜTZ IBCs to your local reseller.

When returnable drums and IBCs are not returned, SCHÜTZ need to make new containers in order to meet demand and help ensure continuous supply of crucial crop protection products.

Manufacturing new containers increases supply chain costs - not returning empties may end up costing you more than just a messy farm!

Don't leave your empty drums and IBCs lying around the farm. There is no charge to return, so get them back to your local reseller and SCHÜTZ will arrange recycling. Together we can work to save money, resources and the environment.

Make sure you don't expose yourself or workers to chemicals by cleaning drums prior to disposal, that's our job. Simply send them back to SCHÜTZ so you can get on with looking after your farm.



GOT A LARGE STASH ON THE FARM?

Contact SCHÜTZ directly to organise an on-farm collection on 1800 336 228 or email salesau@schuetz.net

To find out more, head to returnyourdrums.com.au

SCHÜTZ PACKAGING SYSTEMS

'Golden goose' of salt tolerant wheat varieties to begin field trials

By Andrew Spence

A NEW strain of salt-tolerant bread wheat with genes that can be traced back to wild relatives will begin field trials in Australia this year.

The line known as MW293 has been dubbed "golden goose" by researchers not only for its impressive production but because it takes up large amounts of salt from the soil into its leaves. This challenges previous literature that suggests successful saline tolerant varieties should not absorb much salt.

Researchers in South Australia have been working on the project since the first cross was made between US germplasm W4909 and popular Australian bread wheat variety Mace in 2011.

The 'super line' was then crossed for a second time with Mace to produce a line that thrived in saline soil lab trials, producing twice the grain as Mace in salty soil and also outperforming it in non-saline conditions.

Against the low-salt paradigm

"I couldn't imagine a bread wheat that could accumulate this much salt yet it would be so tolerant because it goes against the current low-salt paradigm," the project's lead researcher Dr Yusuf Genc from the South Australian Research and Development Institute (SARDI) said.

"I call it golden goose because to me it's magical, I've never seen anything like it.

"When we did the analysis of the leaf, what we found was just incredible, there was 100-fold more sodium in the leaf than we normally see in bread wheat varieties. It's very exciting because it's got more salt and more yield, which was not the paradigm at the time because everyone was chasing the idea of sodium exclusion leading to increased yield but that was not the case so it surprised us in a good way.

"Traditionally people have associated salt tolerance with low salt in the plant. They just assumed that if there is low salt in the plant then it will be more tolerant because it is excluding the salt and pumping it back out into the soil."

The research by Yusuf's team was published in the journal Frontiers in Plant Science in October.

This year's field trial will be carried out by SARDI and its research partners at South Australian sites near Roseworthy (non-saline) and at Red Hill (saline) in the state's Mid North or an alternative saline site.

SARDI's Dr Yusuf Genc (left) and Principal Research Scientist, Crop Improvement, Tim Sutton at the Waite Campus's Plant Research Centre with MW293 – the "golden goose".

YET TO REAP RESEARCH BENEFITS

Salinity (presence of salt) and sodicity (presence of sodium) are major constraints to global cereal production. Despite significant international research efforts, farmers in marginal areas are yet to reap the benefits.

Dryland salinity is a major problem for broadacre farmers in Australia, particularly in areas with low rainfall. But, many other wheat producing nations with salinity issues such as the US, Iran, India and China could also benefit from the research.

Two novel populations have been developed to investigate genetic control mechanism of the salt tolerance trait. These are, a doubled haploid population of 200 lines, and recombinant Inbred Line Population of 2000 lines.

This year, field trials will use seeds from about 200 doubled haploid lines from Mace/MW293 cross in saline and non-saline conditions. Next year, the second population of 2000 lines, which contains greater genetic diversity, will be trialled.

Yusuf said the germplasm needed to perform well in both conditions as salinity levels varied from field to field and season to season.

He said a commercial variety was still several years away.

"Our purpose is to get a genetic marker that is linked to the new salt tolerant trait and then use that marker in breeding. This will rapidly speed up the breeding process. We could end up with a variety that is a direct selection from the original lines we developed and that would be fantastic.

"But if we don't then we can still use the marker to make other varieties better - once it's proven, the breeding can be done with any variety.

Genes from wild wheat

Yusuf said the initial work introduced the salt tolerant gene(s) into the bread wheat germplasm line Chinese Spring from a line known as W4909 that was developed from wheat wild relatives and released by the USDA-ARS and Utah Agricultural Experiment Station in 2002.

"The team in the US did an amazing job developing the W4909 germplasm. It was released with no restriction for use in developing salt tolerant lines but as far as we know, it was not utilised in breeding programs presumably due to its high salt concentration in the plant," he said.

"I'm assuming it was considered a dud. We thought it had something special as it grew very well under salinity. We were not discouraged by the fact that it had high salt because our early work in bread wheat already showed that there was no correlation between sodium exclusion and the tolerance to salinity."

Led by SARDI, the research division of Primary Industries and Regions SA, the work was also supported by the University of Adelaide, the University's Waite Research Institute and The Yitpi Foundation.
The research by Yusuf's team was published in the journal *Frontiers in Plant Science* in October, 2019.

■

TO MOVE OR LIFT CHOOSE DIECI TELEHANDLERS

MINI AGRI	AGRI FARMER	AGRI PLUS	HAYMASTER	AGRI MAX
2.5 tonne 5.78 m	*3.0 tonne 6.35 - 8.70 m*	*4.0 tonne 7.00 m*	*4.0 tonne 7.00 m*	*7.0 tonne 9.50 m*

From the compact Mini Agri to the impressive Agri Max, the Dieci range of agricultural telehandlers features machines from 2.5 to 7.0 tonne with lift heights from 5.8 to 9.50 meters.

With a great range of attachments available including baskets, buckets, forks, grabs, jibs and hooks, these versatile machines can handle it all. Built specifically for agriculture, these machines have been tried and tested to be able to combat the toughest Australian conditions. So no matter what you need to lift or move, there is a Dieci for you!

DIECI AUSTRALIA

Call Dieci 1300 888 479 or visit www.dieciaustralia.com.au to find your local Dieci dealer

Fall armyworm incursion: "Not the end of the world"

A NORTH Queensland agronomist, on the frontline of fall armyworm's incursion in Australia, is reassuring growers and advisers not to panic, with early indications the invasive moth could be managed this season through regular monitoring and selective use of insecticides.

Brent Wilson from Nutrien Ag Solutions at Home Hill was the first person to find fall armyworm *(Spodoptera frugiperda)* in the Burdekin Irrigation Area and has been dealing with the new pest since early March. In late May, and for the first time, Brent sprayed a maize crop with chlorantraniliprole (Altacor) targeting fall armyworm after monitoring revealed a significant infestation.

He said the decision to spray had been made after he found 60 to 70 per cent of commercial white corn cobs were infested with fall armyworm larvae in one 54 hectare paddock bordering the Burdekin River at Home Hill.

"This is the worst infestation we have seen since the pest arrived. Prior to this we had found an average of 13 to 15 per cent of maize cobs infested with fall armyworm larvae in any one maize crop," he said.

"In comparison, the white corn crop at Home Hill had two larvae on most cobbs – one at the top of the silk and another one burrowed into the cob, behind the cob leaf and towards the base of the cob. We are hoping, given the crop is in the reproductive phase, that the damage won't have a significant impact on yield. But we did do an aerial spray with Altacor as a control measure within 24 hours of discovering the scale of the infestation."

He said initial inspections post spraying showed "encouraging" results with Altacor appearing to have effectively controlled fall armyworm.

"The general insect pressure in the Burdekin region this season is moderate to high, but what helps is the dispersal of these pests through a range of crops. Essentially having soybean, mungbean, chickpea, sorghum, maize and cane crops all within the irrigation area has a dilution impact on insect pressure," Brent said.

"We have now found fall armyworm in chickpeas, soybeans and sorghum, but maize is definitely its preferred food source in our limited experience."

Fall armyworm larva feeding on maize.
(PHOTO: University of Georgia, Bugwood.org)

Regular monitoring is critical

Brent said he was optimistic the damage to corn in this case was cosmetic, but he warned that, left unchecked, the potential for the new pest to cause significant yield losses was high.

"Regular monitoring is absolutely critical. Get into the paddock. Mark out an area and check it two to three times each week. Make sure you are accurately identifying pests so you can make informed decisions about control measures," he said.

Brent said in cases where fall armyworm larvae infestations in maize crops were below 20 per cent he had opted for regular monitoring rather than insecticide treatment.

"Australian threshold levels have yet to be developed, so we are still relying on the international experience and the advice of our counterparts in places like the United States," Brent said.

"The overseas experience has also shown us how rapidly this pest develops insecticide resistance, so we need to use the chemistries we have in a controlled and measured way to ensure we have them when we need them."

Brent was also keen to see an improvement in the sharing of information about fall armyworm numbers and spread.

"We need industry bodies to share their information about fall armyworm moth flights, as well as any data they have about spread and the build-up of numbers in traps, so growers and agronomists are as informed as possible," he said.

Brent said he would also be supportive of the Australian industry investigating the potential of introducing and registering a fall armyworm virus, called FAWligen, that has been used as part of a suite of pest management tool overseas.

"I think it could be worthwhile assessing whether this product could be bought into Australia and how it would work in our farming systems and what the risks might be to beneficial insects and other insect populations."

Be alert, not alarmed

In the meantime, Brent's message is "don't panic" – the arrival of the pest was not "the end of the world".

"We have control measures at the moment that are effective and with regular monitoring we can be strategic and considered about how we use these controls," he said.

"And the stark reality is for many of us, including growers in the Burdekin, helicoverpa is still the number one pest threat."

Grains Research and Development Corporation (GRDC) Manager Biosecurity, Jeevan Khurana said the GRDC was currently working closely with industry partners to characterise the pest, estimate potential impacts and develop management options, as well as to identify and prioritise research, development and extension gaps.

"The GRDC is also in the process of producing a series of podcasts to help guide grower and adviser decision making around fall armyworm," Jeevan said. "We have collated information resources on fall armyworm, including an overview of emergency use permits on the GRDC website.

For support identifying fall armyworm go to *https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/fall-armyworm*. To report a sighting in Queensland, call DAF on 13 25 23 or the Exotic Plant Pest Hotline 1800 084 881.

Growers or agronomists are also encouraged to share their experiences of fall armyworm on Twitter using the hash tag #FAWAus so others in the industry can benefit from their knowledge. ■

Select® Xtra

Xtra Quality. Xtra Strength.

- Unique patented Xtra load 360g/L formulation
- Built in surfactants for improved spraying quality & crop safety
- Stabilised formulation to maintain efficacy over time
- Selective grass control in canola

www.upl-ltd.com/au

UPL OpenAg™

Getting the weed optics right: A case study

By Cindy Benjamin, WeedSmart

GLENN Coughran, Beefwood Farms' manager, has used optical sprayers as the foundation of a rejuvenated weed control program over the past 14 years and seen the benefits of combining this technology with autonomous tractors over the past five years. The combination allowed for more efficient and targeted use of herbicides through double knocking and more timely and frequent applications to treat weeds at their most susceptible growth phase.

With low weed density across the 11,000 hectare operation Glenn is able to avoid the use of pre-emergent herbicides, which have limited crop rotation choices in the past, particularly in years where summer rainfall has been low.

Glenn is keen to see 'green-on-green' optical weed detection become a reality and is working closely with AgriFac to have this technology integrated into their spraying equipment.

From livestock to controlled traffic

Located between Goondiwindi and Moree on the western side of the Newell Highway, Beefwood Farms is an aggregation of six neighbouring properties, all operated from the central workshop area. Gerrit and Pam Kurstjens, originally from Grubbenvorst, the Netherlands, purchased the aggregation in 2006 and began the transition from livestock to a controlled traffic continuous cropping operation using the latest technologies to achieve greater efficiencies.

"Our cropping program has to respond to the weather, and to a lesser extent prices, but normally the sequence is wheat then barley then chickpea or left out for winter and into sorghum in summer," says Glenn. "We are keen to try dryland cotton but unless we have conditions that result in a full profile of soil moisture it just isn't a feasible option."

"Each year we fallow about 20 to 25 per cent of the farm in winter in preparation for planting the summer crop," he says. "If the sorghum is off soon enough these paddocks are usually double cropped back to chickpea the next winter. This tactic gives us two consecutive winters to work on any winter grass weeds, particularly wild oats, using different chemistry."

Beefwood Farms manager, Glenn Coughran.

But with a string of very dry years recently the opportunities to grow summer crops have been limited.

They generally avoid using residual chemistry in summer due to concerns over the possibility of insufficient late summer rainfall to breakdown the chemical prior to planting the winter crop.

"We have been caught using imazapic in a summer fallow and then we didn't get the necessary 150 to 200 mm of rainfall needed to break down the residual," he says. "This meant we had to grow Clearfield barley, which was a good option in the circumstances, but you are restricted to just a few varieties and we don't want to be limited in our crop choices too often."

CTF based on 3 metre centres

The CTF system is based on 3 metre machinery wheeltrack centres, 12 m headers, 24 m planters, 48 m self-propelled boom sprayers and 24 m WEEDit optical sprayer. Beefwood operates two NDF disc planters for the winter cropping program – a double bar machine planting on 33 cm row spacing and a newer single bar machine where the closest spacing they could achieve is 37.7 cm. The sorghum crops are sown on 1.5 m row spacing.

"We can't sow the cereals any closer to increase crop competition but we have seen a response to increased seeding rates," says Glenn. "Also, the whole farm is planted east-west to maximise shading in the inter-row. This helps a little in the sorghum too where increased seeding rates would not create any competition outside the row."

In drier years Glenn will often increase the area sown to barley as it has a greater competitive ability and tends to perform better under marginal soil moisture conditions than wheat.

Herbicide program

Beefwood Farms' consulting agronomist is Stuart Thorn, a director of MCA Ag, Goondiwindi. Stuart oversees the herbicide program for the operation, including recommendations for herbicide mixes and rotation of herbicide modes of action.

"Bringing in new country into our cropping program usually involves tackling large weed populations such as a recent acquisition where barnyard grass was a big problem and we used residuals to help regain control," says Glenn. "Residuals have also helped with feathertop Rhodes grass, and then we backed away once the problem was under control, which usually only takes a few years."

In the fallow Glenn uses a double knock of glyphosate applied as a blanket spray and then followed up with paraquat to treat any survivors using the optical sprayer. They also use glyphosate at robust rates through the spot sprayer and no longer mix glyphosate and 2,4-D.

To stop weed seed set in-crop Glenn will often implement a late spray of a Group Z grass selective herbicide, flamprop-m-methyl, to patch out weedy areas of wild oats in wheat. Chickpeas are always desiccated to prepare the crop for harvest and this can have some weed control benefit going into the fallow.

Fungal disease control in every droplet.

BAYER

Aviator® Xpro®

Group 3 Fungicide
Prothioconazole

Leafshield™
Rainfast in under an hour in most conditions

Group 7 Fungicide
Bixafen

Control a wide range of diseases in barley and wheat with Aviator® Xpro®.

Barley	• Net form net blotch • Spot form net blotch • Leaf rust • Powdery mildew • Leaf scald
Wheat	• Septoria tritici • Septoria nodorum • Eyespot • Powdery mildew • Yellow leaf spot • Stripe rust

- Two different mode of action groups to help tackle fungicide resistance
- Apply by ground equipment or aircraft
- Also registered for use in canola, chickpeas, faba beans, field peas and lentils

Talk to your advisor or scan the QR code to learn more about Aviator Xpro use in cereals.

aviatorxpro.com.au

Beefwood Farms is working closely with Agrifac and Bilberry to bring green-on-green weed detection and spraying to reality.

Beefwood Farms owner, Gerrit Kurstjens (left) with his daughter Marieke and MCA Ag agronomist Stuart Thorn.

Picloram applied in cereals to control broadleaf weeds such as sowthistle also provides a residual effect to reduce fleabane germination in July/August.

"Maintaining stubble and ground cover is our number one priority so there is no cultivation for weed control or any other purpose," says Glenn. "Our best chance to grow competitive crops is to have stored soil moisture."

At this stage Glenn has not implemented any harvest weed seed control measures at Beefwood but he is keeping an eye on developments. Due to the loss of stubble involved, they will not adopt narrow windrow burning but other tactics that maintain and spread stubble cover would be considered if the need arose.

Automation for spot spraying works well

Having already seen the chemical savings and the weed control benefits of using optical spraying technologies for over 10 years, Gerrit and Glenn were looking for ways to extend the value of the technology to achieve even greater efficiency with chemical use, particularly in fallows.

"Gerrit has contacts with the Dutch company, Precision Makers, who had developed software for autonomous lawn mowers, and in about six months they had made the necessary modifications and installed the software on a Fendt 936 Vario tractor that we had on the farm," says Glenn. "We found the autonomous tractor paired with the optical sprayer was a perfect fit, allowing us to spray 24 hours a day if conditions are right and to spray on the weekends without adding to our labour costs."

After a few years they purchased a John Deere 8345 tractor, also fitted with Precision Maker equipment.

Over the past 10 years the optical spray operations have applied herbicide to an average 2 to 8 per cent of the field area, using robust rates, but this is still far more economical than blanket sprays.

"We know it works very well when weed density is low. Now we can use the autonomous tractor to spray more frequently than you would with a driver, we have started pushing the boundaries and using the optical sprayer in paddocks with weed density of 30 per cent, knowing that we can keep coming back," says Glenn. "Even at a higher herbicide rate this is cheaper than a blanket spray operation. The more often we go back the less large weeds there are and we are spraying smaller weeds that are easier to kill."

In a recent spray job on 3500 hectares of fallow the optical sprayer activated spray nozzles on just 0.7 per cent of the area, at a cost of $0.24 per hectare for chemical, without a driver.

"Using the autonomous tractor is not about reducing our labour force," says Glenn. "The person who used to drive the tractor is still looking after the spray job. The other job that is perfect for the autonomous tractor is tram track renovation."

Every three years – usually following chickpeas when there is less crop residue – the tractor operates a TPOS flat track renovator along the 2 to 6 km long CTF wheeltracks – saving someone from a very boring job.

Having proven the value of automation to the farming system at Beefwood Farms, they have been forced to put their work in this area on hold after John Deere bought out the automated machinery component of Precision Makers in 2019 and have decided to concentrate on automated mowers for the turf industry. They are currently not servicing the automation software that Beefwood Farms had installed in two tractors.

"Unfortunately, until we find a suitable alternative, we have had to go back to fully conventional operations for spraying," says Glenn. "It is hard to accept when we have seen the benefits of automation for these routine operations."

A few years ago, Beefwood Farms bought a 48 m AgriFac self-propelled sprayer to increase their spraying capacity for blanket sprays and fallow spot spraying. The AgriFac sprayer is twice as wide as the WEEDit boom and can travel at twice the speed of the autonomous tractor, so even though there is a driver they are covering three to four times the area.

Green-on-green spraying

Beefwood Farms is also on the cutting edge of the latest innovation in weed detection and herbicide application, working with AgriFac and Bilberry in the testing of green-on-green spraying.

Since purchasing the AgriFac SP sprayer they have been keenly observing the advances in the artificial intelligence, or machine learning, and assisting with the field testing.

To work in-crop the software on the sprayer needs to interpret the images from the camera, distinguish a weed from surrounding crop plants and then identify the species and size of weed. Within moments the sprayer needs to respond and deliver the correct herbicide at the right rate to the identified weed.

"The expectation is that the sprayer will be able to treat a 'site' of 30 cm square with exactly the right product at the right rate," says Glenn. "This is really exciting technology and once it is fully developed we see no reason why it couldn't be used autonomously."

For more information visit the website: *www.weedsmart.org.au* ■

WEED smart
every weed every seed
every farm every year

ASK AN EXPERT –

IS IT SAFE TO ASSUME THAT POOR WEED CONTROL IS DUE TO HERBICIDE RESISTANCE?

With Maurie Street, CEO, Grain Orana Alliance (GOA)

IF a grower experiences a poor spray outcome on annual ryegrass with glyphosate – or seemingly needs to continually increase rates to achieve the same level of control – it might seem obvious that herbicide resistance is the most likely problem.

On the contrary, Maurie Street, CEO at Grain Orana Alliance says that this is not always the case, having investigated ways to regain control of problematic ryegrass populations.

"Annual ryegrass has always been present on most farms in the Central NSW cropping region and many populations are resistant to Group A and B herbicides," says Maurie. "So, when growers started to have trouble controlling this weed with glyphosate it seemed natural to assume that populations were becoming resistant to our most relied on knockdown herbicide."

In an effort to finesse the available control options, GOA established trials over three years with GRDC investment on seven sites where poor control of annual ryegrass over previous years had resulted in increased weed seed banks.

"The first thing we did was collect samples from each site and have them tested using the *Quick Test* method for glyphosate resistance," says Maurie, "We were surprised to discover that five of the populations were in fact susceptible, even at lower label rates of glyphosate, and the other two populations were

Grain Orana Alliance CEO Maurie Street says growers and agronomists need to critically assess any spray job that does not achieve the expected results. (PHOTO: GRDC)

only moderately resistant to the lower rate and 100 per cent susceptible to higher label rates."

What this suggests is that there can be something other than resistance contributing to herbicide failures. Testing will reveal if herbicide resistance is at play and identify herbicide products and rates that can be expected to provide acceptable control.

Next, critically assess the spray operation and identify factors that could have affected the efficacy of the spray job.

Finally, look for ways to implement the WeedSmart Big 6 tactics in your weed control program to keep weed numbers low.

So, if the ryegrass was susceptible to glyphosate, why was control poor?

Short answer: Most likely a combination of reasons.

Longer answer: Instances of poor weed control after a herbicide application could be associated with one or more factors such as poor spray water quality, incorrect spray timing, inappropriate sprayer set up delivering less than optimal spray droplet size and/or water rates, products with sub-optimal surfactant loadings, or environmental stress affecting the plant and or the herbicide activity. Or in some cases, the herbicide rate is too low for the job at hand.

In the event of an apparent herbicide failure, review and investigate all aspects of the application – including Stress, Timing, Application and Rate (STAR). Don't just assume that herbicide resistance is to blame.

In the paddocks used for this trial, early testing for herbicide susceptibility would have revealed that glyphosate was still effective, although some higher application rates would be needed in some fields to achieve adequate levels of control.

Attention could then be turned to other factors that might have caused the poor control of annual ryegrass in these paddocks.

Trials that ran at seven sites for three years revealed that many things can contribute to a spray failure and growers should not rush to the conclusion that herbicide resistance is always the cause.

Is it safe to use higher rates of glyphosate and how does it help?

Short answer: Using a rate at or near the upper end of the allowed range for glyphosate can improve efficacy in both resistant and susceptible populations. Always stay within the label rate range when applying herbicide.

Longer answer: In the case of glyphosate resistant plants, the resistance is often still rate related. Consequently, increasing product rates will effectively control plants with lower level of resistance.

In the case of both resistant and non-resistant plants, increasing glyphosate rates may contribute to more effective control by counteracting poor application, improving control of older or stressed plants, overcoming reduced efficacy due to using poor quality water and when treating plants covered by dust. Higher label rates can also improve glyphosate activity on plants exposed to the higher temperatures that can arise in early autumn or late spring.

In these GOA trials the use of higher glyphosate rates gave acceptable control in all but one paddock. The population in question was confirmed susceptible and although the application conditions were noted as 'very dry and the weeds somewhat stressed with warm spray conditions', another trial site sprayed under similar conditions, using the same water source, spray set-up and products achieved acceptable control.

The reason for the failure on a susceptible population was not confirmed in the trial but highlights the importance of susceptibility testing both to determine if resistance is a contributing factor and if increasing the application rate is likely to be an effective strategy.

What's more important, adjuvants and surfactants or product rate?

Short answer: Generally speaking, increasing the product rate gives the most consistent improvement in control.

Longer answer: In the trial, a range of glyphosate formulations, adjuvants and surfactants were tested for efficacy at the seven sites. There was no consistent difference in performance of Roundup CT, Roundup Ultra Max (a premium, fully loaded product) and a low priced generic brand, if robust rates were used. At the lower rates tested, Roundup Ultra Max often performed better than the other two products tested.

Similarly, when surfactants or additives were applied with robust rates of glyphosate there was no consistent advantage to the addition of BS1000, LI700, Liase, Wetter TX or Activator.

At lower glyphosate rates, the addition of these surfactants sometimes improved control, but often not to the levels achieved with higher rates of glyphosate, and the response was inconsistent. Having said this, if surfactants or additives are required to improve water quality they should always be used. ■

HOW TO ASK A WEEDSMART QUESTION

Ask your questions about glyphosate resistance on the WeedSmart Innovations Facebook page WeedSmartAU, Twitter *@WeedSmartAU* or the WeedSmart website *https://weedsmart.org.au/category/ask-an-expert/*

'WeedSmart' is an industry-led initiative that aims to enhance on-farm practices and promote the long term, sustainable use of herbicides in Australian agriculture.

Soil test to optimise fertiliser expenditure this winter

WITH many farm budgets looking tight following the run of desperately dry seasonal conditions, grain growers will be anxious to maximise the value of fertiliser expenditure this winter.

As one of the largest single variable costs for farming operations, it's important that fertiliser programs are well planned in terms of requirement, product and placement to ensure they deliver dividends in crop yield and grain quality.

Incitec Pivot Fertilisers agronomist Bede O'Mara said the most effective strategy started with segmented soil testing to quantify the reserve of carry-over and mineralised nitrogen (N) and its position in the soil profile.

Bede was speaking at the Grains Research and Development Corporation (GRDC) annual Grains Research Update in Goondiwindi, in southern Queensland, earlier this year.

"It's important to understand where you are in terms of N availability because even though generally it's been very dry, it is possible that some mineralisation has occurred in areas that have seen small falls," he said.

The mineralisation process converts N to plant available forms and is driven by soil temperature, moisture and levels of organic matter. Mineralisation generally occurs slowly during drought and increases strongly once it rains.

"Testing will be especially important in the 0–10 cm and 10–30 cm bands as that's where most of the mineralisation will have occurred with sporadic falls of rain," Bede said.

"But, N could also be sitting deeper in the soil profile – depending on the amount and intensity of falls, previous fertiliser applications or soil N could have moved to the 30–60 or 90 cm profile depths, particularly if the soil was cracked and open prior to the rain.

"Basically, soil testing can remove the guesswork in terms of N requirements and the risk of unnecessary expenditure.

"If necessary, that spend can then be directed to other ameliorants such as gypsum or lime, or other nutrients such as phosphorus (P), zinc (Zn) and potassium (K) which may be limiting given the dry season and potentially low levels of arbuscular mycorrhizal fungi (AMF)."

AMF and long fallows

Previously known as vesicular arbuscular mycorrhizal or VAM fungi, AMF could be low on long fallow country which may affect a crop's ability to access nutrients such as P and Zn.

AMF populations can suffer from a lack of host plant roots during long clean fallow periods or drought, with severe reductions showing up as a syndrome known as long fallow disorder – the failure of crops to thrive despite adequate moisture.

As crops vary in their ability to grow without the AMF fungi, crop selection is an important part of helping address low AMF situations.

Some crops such as winter cereals can grow in paddocks that are low in AMF while boosting AMF levels for the next crop.

By comparison, crops such as linseed, sunflower, mungbean, chickpea, maize and sorghum all have over 50 per cent dependency on AMF and therefore yield may be compromised in paddocks where low AMF is an issue.

AMF levels can be assessed using PREDICTA B testing, allowing growers to identify at-risk paddocks and if necessary, alter rotations to a crop less dependent on AMF and/or attempt to ameliorate paddocks with additional nutritional inputs such as P and Zn.

"At the end of the day, soil testing allows growers to make site specific objective judgements on the right treatment for each paddock and gives them the best chance to grow a productive and profitable crop," Bede said.

Fertiliser and soil nutrition management were key discussion topics at the Grains Research Updates in Queensland and New South Wales. To read papers from the 2020 Updates, go to *https://bit.ly/3axok58.* ■

Queensland grower Paul McNulty and Bede O'Mara (right) discuss fertiliser stratrgies for 2020.

The Nebraska Test

By Ian M. Johnston

In February 1916, US Congressman Wilmot F. Crozier purchased a tractor. He could never have conceptualised the far reaching consequences by so doing.

The tractor he purchased was a Ford Model B – and surely there could not have been a more reputable brand name throughout the whole of America, than Henry's Ford! But sadly and significantly as it turned out, Crozier's Ford B tractor had no correlation whatsoever with the illustrious Henry. In fact, the tractor was a fraud!

The Ford 'B'

The perpetrator of the deception was a devious opportunist named W. B. Ewing. Knowing that Henry Ford was planning to release his new Model F tractor in 1917, Ewing, who owned a small steel manufacturing business in Minneapolis, irresponsibly rushed through the production of a farcical three wheeled tractor.

He happened to employ an apprentice youth, whose name was Ford. Insidiously, he instructed the young Ford to append his signature to the blueprint design of the monstrosity. He then rushed the signed document off to the Federal Patent office, where he succeeded in patenting his 'Ford' tractor Model B. (Why B?). The year was 1915.

Two years later, Henry Ford's application to patent his new Model F tractor under the name of 'Ford' was rejected, as there was already a tractor patent allocated to a 'Ford'. Accordingly, Henry was obliged to change the name of his new creation to 'Fordson'.

For the record – Ewing's Ford B was powered by a Gile marine 16 hp twin cylinder horizontally opposed engine, originally designed as an auxiliary for small sail boats! The three wheeled tractor was propelled by means of the two front drive wheels through an exposed bull gear and pinion arrangement.

Ford B – the sole remaining example. Lester Larsen driving.
(PHOTO: Roland Spence)

Wilmot F. Crozier.

Congressman Crozier

Willmot F Crozier of Polk County, apart from being a Nebraska State Legislator, was also a prominent gentleman farmer with considerable influence in government affairs, who rapidly came to the conclusion that his Ford B was a disaster! It proved to be totally unreliable and repeatedly had to be dragged out of the paddock in a broken down state by a pair of Clydesdales.

Appeals to Ewing proved utterly unproductive. He ignored letters of complaint and adopted a disposition of complete indifference to the problems.

In a state of frustration and anger, Crozier abandoned the Ford B and replaced it with a brand new Big Bull tractor, manufactured by The Bull Tractor Company of Minneapolis. Upon its arrival at his farm, Crozier experienced a feeling of trepidation when he noted the Big Bull was powered by the same make of engine as his Ford B. It was also a three wheel design, but in the case of the Big Bull the single wheel was located out front, and quite remarkably – only one of the two rear wheels propelled the unit.

The Big Bull proved nearly as unworthy as the Ford B. Crozier was not happy! Further, as he drove around his home state of Nebraska, he discovered that many farmers shared his displeasure with unethical and unprincipled tractor manufacturers, many of whom were taking advantage of the fact that most farmers had no previous tractor experience.

Senator Charles Warner, a close friend of Crozier, also experienced tractor problems and in frustration they jointly sponsored a bill which became law in the State of Nebraska in July 1919.

The bill stipulated that no new tractor could be sold in the State of Nebraska unless the manufacturer had been issued with a licence, which stated that a certificate for each tractor had been

Ford B – frontal view. Note 2 cyl. Gile engine. (Photo Vern Anderson)

Ford B and Graham Bradley on trailer. (Photo (IMJ)

obtained from The Agricultural Engineering Department of the University of Nebraska. This could only be acquired following a series of strict testing procedures by a hastily convened University Tractor Test Board.

The Nebraska legislation

The new legislation had a dramatic consequence over the entire North American tractor industry. Nebraskan farmers accounted for a significant share of the total number of tractors sold in the USA and no tractor manufacturer could contemplate the withdrawal of their marketing operations in that State. Accordingly, all new tractor models, with very few exceptions, were submitted to the Nebraska Test Facility, where they underwent a series of rigorous testing to determine their adequacy and reliability, prior to being issued with a compliance certificate.

The engineering design of tractors rapidly advanced, as manufacturers could not contemplate the disgrace of having their claimed performance figures rejected. In addition, farmers welcomed the opportunity of being able to inspect the test results of a particular tractor prior to making a purchase.

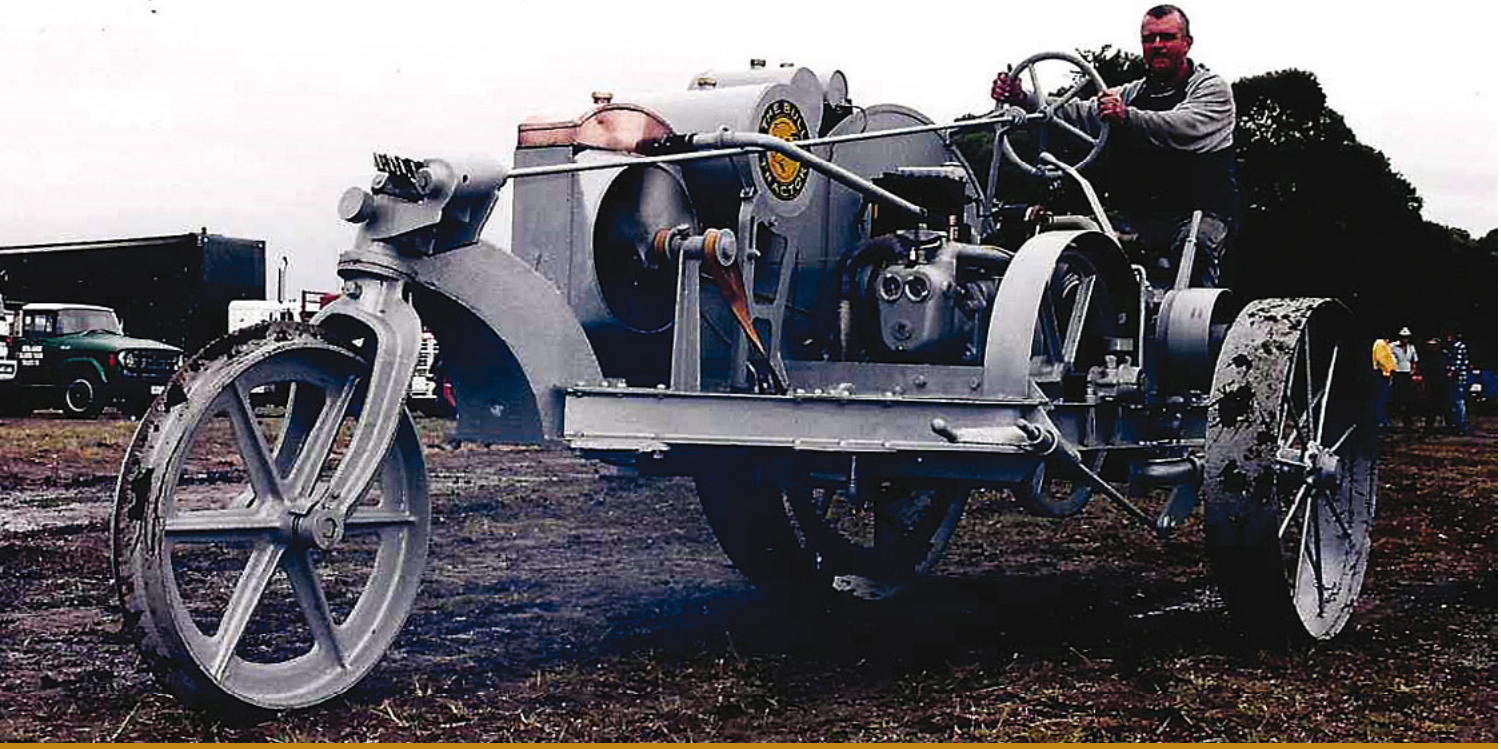
The first tractor to be tested (Test No. 01) at the Test Facility was submitted by Deere and Co. and occurred on March 31, 1920. The tractor was Waterloo Boy Model N, manufactured by the Waterloo Gasoline Engine Company, which had recently been acquired by the John Deere organisation.

Interestingly, at the end of 1930 an Eagle 6A, submitted by The Eagle manufacturing Company of Appleton, Wisconsin, was tested and designated Test No. 184, indicating that over a 10 year period, 184 tractors had been tested. A decade later – 1940 – an Oliver 80 was Test No. 365, indicating a further 181 tests.

In 1934 manufacturers were advised that the Facility was now prepared to accept tractors mounted on pneumatic tyres. Hitherto, the popular belief was that unless a tractor was mounted on steel wheels fitted with spud or bar grips, it would be incapable of obtaining proper traction.

Test No. 223 proved that such was not the case, when in 1935 an Allis Chalmers Model C mounted on pneumatics recorded a drawbar pull of 1402 pounds at 3.23 mph. The same tractor when mounted on steel wheels returned a lesser drawbar pull of 1201 pounds, but at the slightly higher speed of 3.79 mph.

On April 9, 1940, Test No. 339 was of a Ford 9N equipped



1915 Bull at a Victorian rally, brilliantly restored by Norm Johnson. (Photo IMJ)

with Harry Ferguson's 3 point linkage and draught response control. But the advanced design was too premature for the test engineers, as they had not yet developed a system of evaluating the benefits of the Ferguson Hydraulic System.

The updated facility

The Nebraska Tests were discontinued during the World War 2 period, but were resumed in 1946 under the direction of Lester F. Larsen, the newly appointed Engineer in Charge. Updated equipment items were installed, including a 400 hp dynamometer, designed to be driven by a power take off shaft. Hitherto dynamometer testing was performed using a flat endless belt attached to the tractor's belt pulley.

Additional equipment was installed to measure hydraulic lift capabilities, crash resistance of roll over protection systems and decibel readings within the interior of cabins.

A much larger test laboratory was constructed and, with the introduction of crawler tractors into the system, the original gravel surface of the test track was replaced by concrete paving.

Testing at the facility continues today unabated. Manufacturers

Test monitor vehicle equipped with high tech electronics. (Photo IMJ)

must pledge that the tractor submitted is a stock model randomly selected. Additionally, a factory representative must be present during the entire testing procedure.

The Test Laboratory is now currently capable of testing engines up to 1000 horse power and engine revolutions up to 12,000 revs per minute.

Tailpiece

Following 29 years of service, Lester Larsen retired but was encouraged to establish a Nebraska Test Museum, within the original test laboratory at The University of Nebraska. The museum is currently the custodian of over 40 magnificent examples of early farm tractors.

Some years ago, during a visit to Lincoln, the capital city of Nebraska and the home of the Tractor Test Laboratory, I was privileged to be introduced to Lester Larsen by a distinguished tractor collector named Vern Anderson, whom I had arranged to visit and inspect his rare 1938 Graham Bradley. (More on that in a future article).

Upon being introduced, Lester Larsen personally escorted me through the museum and I was delighted and thrilled to be shown the sole remaining example of the iniquitous Ford B. ■

University of Nebraska Tractor Testing Laboratory. (Photo IMJ).

IAN'S MYSTERY TRACTOR QUIZ

Question: Can you name this historic 1917 Australian tractor?

Degree of difficulty: Easy if you are a fair dinkum Aussie.

Clue: It was made in Ballarat, Victoria.

Answer: See page 48.

In collaboration with the Society of Precision Agriculture Australia, Australian Grain presents a series of articles on a wide range of precision agriculture technologies helping you put PA to Work on your farm.

Contracting leads to variability plan

By Rebecca Thyer

Although he grew up around grain farms in Central Queensland, it was while contract farming and harvesting that Luke Bradley started thinking more about variability.

In an area that stretches about 2500 km from Queensland's Richmond to Uralla in NSW, Luke was contracting up to 20,000 hectares. It gave him the chance to mull over the variability he was seeing – and on-farm responses.

"It was easy to see there were enormous variations in fields. Yet, they were all being treated the same way, in regard to seeding rates and nutrition. It was a 'we've always done it this way approach'."

Luke says this was happening despite most farming equipment being able to observe and store data – and in many instances – vary rates. It led Luke to look more closely at his home farm.

"I started to think, we need to be flexible to deal with our seasons to decrease risks both environmentally and financially. We have the ability to treat areas differently – and the equipment and technology to do that – we just need to make sure it is worthwhile."

Luke Bradley says – "Treating areas differently can decrease environmental and financial risks."

This thinking eventually led Luke to pursue a Nuffield Australia Farming Scholarship, but in reality, contracting was Luke's first scholarship.

Home and away

The lessons learned contracting he took home to Springsure in Central Queensland where he farms 5300 hectares with his wife Sophie and parents Peter and Kerrie.

Together they crop 4000 hectares of sorghum, barley and wheat and run a 300-head beef cattle herd.

Luke had collected crop yield data for seven years and had begun to benchmark their water use efficiency (WUE) with farm consultancy Agripath.

Farm details…

Location: Springsure, Central Queensland.

Farm size: 5300 hectares.

Rainfall: Annual 603 mm.

Soil: Alkaline self-cracking clay with a pH of 8 to 9.

Enterprises: Sorghum, corn, chickpea, wheat and barley cropping, plus a beef cattle operation.

Personnel: Luke and wife Sophie, and Luke's parents Peter and Kerrie.

Yield: Three tonnes per hectare of sorghum.

The farm's annual average rainfall is meant to be 603 mm. But Luke says the past four years have seen them record their worst 12, 24, 36 and 48 months in a 132-year record keeping history. Although they still "turned over some grain." Water and its use is paramount for their dryland operation.

"Water is the main variable we need to manage, yet the one we have least control over. WUE and nitrogen or nutrient use efficiency (NUE) go hand in hand, and we need to maximise both. If you don't have an agronomic system in place that maximises WUE, like stubble retention, then any NUE efforts won't work."

The benchmarking with Agripath helped show the Bradleys their WUE rates based on the season and production. "It was all good, but it was still an overall average. I wanted that information to be more defined."

Would variable rate be worthwhile?

So, Luke, an industrial electrician by trade and happy to spend time exploring and interpreting data, started his own calculations. He wanted to work out whether creating and implementing variable rate nutrition prescriptions would be worthwhile.

Using readily available WUE data sets from the GRDC for sorghum and a software program called 'Agrian' he began the work. Luke explains that he exported his harvest yield files to the program and shifted the parameter bars to include nine nutrition zones, building a spread sheet for sorghum yields, based on varied inputs.

That work began to justify the costs involved with creating a variable nutrition program. "It showed a seven per cent return on investment if we developed prescription maps for our urea.

"This is the data I wanted to justify spending money on changing our nutrient management. I was not re-writing the book but just taking that readily-available information and adding it into our business risk profile to create prescription maps."

Building the maps

With step one – the justification – done, Luke began the process of building the maps. For that, he involved 'Echelon', a PA solutions company.

Echelon offered the Bradleys variable rate (VR) services that are quite common in the US, Luke says.

Top PA tips…

- Using readily available, public and on-farm data you can make financial and environmental justifications for varying inputs, such as nutrients.
- Historic NDVI biomass data can be found on-line if you have not collected it previously.
- Water and nitrogen use efficiency go hand in hand but dryland farmers have no control over water. Biomass maps can help show where water is available.
- Be prepared to learn and tweak your thinking. I thought I knew everything about WUE; now I realise there is plenty still to learn.

"And we decided it was worth doing VR for our sorghum on our 4000 hectares through one of their programs."

Although Luke had run some calculations himself, he says Echelon was able to offer a more detailed program, using extra data that included historic NDVI biomass data from satellites.

"I was not re-writing the book but taking readily available information to create prescription maps."

The colours on the NDVI map (Figure 1) show the average rate of biomass across the field. The red zones show where the biomass is less vigorous and are in Luke's lower plant available water (PAW) zones. In contrast, the darker green zones are where more water is available.

The maps help with Luke's aim to match WUE and NUE. "The areas that we will get more production from, those with a higher PAW content, will receive more nutrition. And vice versa."

Now Luke runs a continuous variable rate nutrient program. "It's scary when you see the controller changing all the time, but it is working well."

Urea used to be blanket rated at 120 kg per hectare for sorghum. Based on financial risk, Luke decided his urea outlay was still to average 120 kg per hectare across the paddock, but it would be applied at varying rates, with Echelon's help.

"Based on the prescription maps for sorghum, we now spread 60 kg per hectare in low yielding areas and up to 240 kg per hectare in the high production areas."

These prescriptions maps are very similar to Luke's initial maps that gave him the confidence to go to VR.

Luke runs all John Deere software and the maps developed by Echelon were compatible with this and worked well. "John Deere software means we can use third party providers for other jobs and put that information or decision modelling back into our farm machines."

Machinery-wise, the Bradleys added ISOBus-approved equipment on spreaders and sprayers, so all rate controllers are aligned with John Deere software and systems. Most people have the hardware that can be equipped cheaply with rate controllers. We have not changed the method of application, just the rates.

The plan is working well, and Luke has seen more than the seven per cent return on investment that he had originally calculated as part of his justification.

"We have probably surpassed that calculation and spent less too. Inputs are focused on the 60 per cent of the paddock that makes the money."

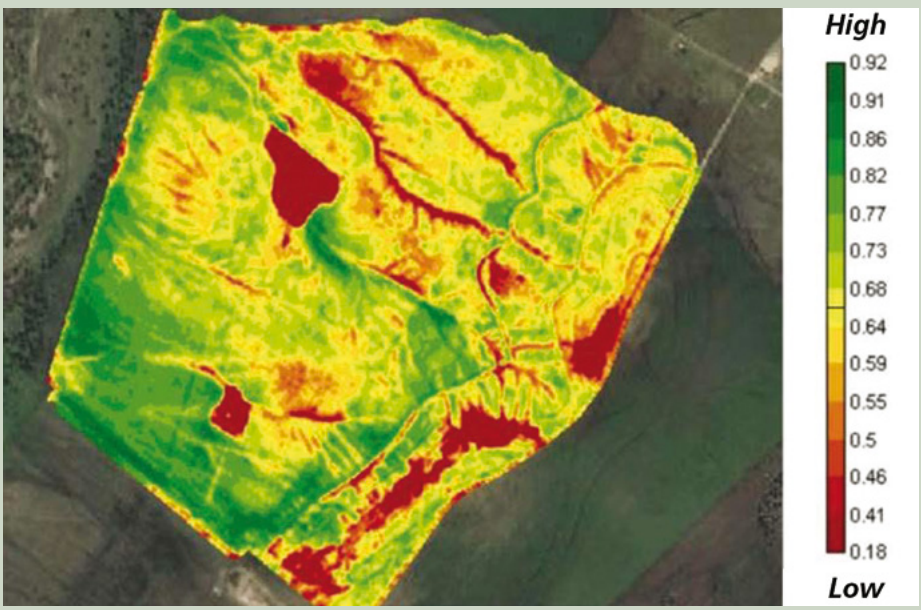
As well as the financial gains, he says that the change is also important to the environment. The family farm falls in the Great Barrier Reef watershed, where cane farms are already being regulated on crop nutrition. "We've seen it happen to cane farmers and I think the reef regulations will become more strict. Our job is to use best practice and innovation to the best of our ability.

"Our spreaders and spray rig are all VR capable so we are organised and ready for any regulatory changes that may happen."

The future

Luke says he is only at the very beginning of where PA tools and technology will take him and the farm.

FIGURE 1: The colours on this NDVI map show the change in biomass across the field



The red zones show where the biomass is less vigorous and are in Luke Bradley's lower plant available water (PAW) zones. In contrast, the darker green zones is where more water is available. Luke aims to match PAW to nutrition. "The areas that we will get more production from, those with a higher PAW content, will receive more nutrition. And vice versa." He says the image is a good example of the variation across his farm.

"For example, we have levels of sodicity at about five per cent exchangeable sodium on 1400 hectares. I know we could address it, but it is cost prohibitive to fix with a blanket rate of gypsum across this area, especially as it is also costly logistically to transport that amount here."

But undertaking some EM38 work – to provide a measure of soil electrical conductivity and converting this to soil type and sodicity mapping – is helping to identify the areas that will benefit most from treatment.

"I still need to justify what will be the benefit if we do spread gypsum and the income we will get from that decision."

Another plan is to look at the evapotranspiration (ET) in the fields.

"I've talked to a few companies about this, to learn how well our total ET in crop and in season compares against WUE.

"Doing so will allow me to assess how well we are set up for making the most out of a season. By that I mean – how well is our stubble management working, our rotations, our move to narrower rows, if we should plant more cover crops or not plant in certain areas. We have the ability to treat areas differently – and the equipment and technology to do that – we just need to make sure it is worthwhile."

Scholarship

It has been a busy few years for Luke. Not only does he (and his family) run the grain and cattle enterprise, but he has undertaken a Nuffield Australia Farming Scholarship.

Supported and often joined by his immediate family, Luke has travelled to the US, Argentina, Brazil and New Zealand to see PA and intensive farming in action.

Luke says he wanted to look at similar climates and situations to his.

Building on what he learnt in Australia, one of Luke's memorable moments was meeting Dr Bob Stewart from West Texas A&M University, who leads the university's Dryland Agricultural Institute.

"I thought I knew everything about water and WUE until I went to Texas and met Bob," Luke recalls.

He says Bob taught him to think about how water is turned into grain. "It is all very well looking at the research data, but how do you manipulate it to your farming system? It's not just about the rain that falls, but also about the water lost through transpiration and evaporation."

Luke is starting to build a system that correlates to these learnings, improving water use.

"We used to have wider rows and have moved to narrower rows (within our CTF system). That should see us grow more biomass in the plants and more organic matter in the soil. Future steps also include considering different harvest options."

Contact Luke Bradley, M: 0400 324 441, E: woolaroo5@bigpond.com @woolaroo5

Luke's Nuffield presentation is available at *https://www.nuffield.com.au/luke-bradley-2017* ■

As a Nuffield Farming Australia scholar, Luke (right) met Dr Bob Stewart from West Texas A&M University (left). Being a dryland grower, Luke thought he knew everything about water and WUE until he met Bob, who taught him to think about how water is turned into grain.

Study reveals minimal impact from CSG hydraulic fracturing

A COMPREHENSIVE three-year scientific study into hydraulic fracturing (HF) associated with seam gas wells in Queensland, has found little to no impacts on air quality, soils, groundwater and waterways.

The study also found current water treatment technology used for treating water produced from coal seam gas wells is effective in removing hydraulic fracturing chemicals and naturally occurring (geogenic) chemicals to within relevant water quality guidelines.

Research objectives for *Air, Water and Soil Impacts of Hydraulic Fracturing in the Surat Basin, Queensland*, conducted by the CSIRO's Gas Industry Social and Environmental Research Alliance, were developed in response to community concerns about the potential for chemicals used in hydraulic fracturing operations to affect air quality, soils and water resources.

The study analysed air, water and soil samples taken before, during and up to six months after hydraulic fracturing operations at six coal seam gas wells in the Surat Basin in Queensland.

Insights into impact across Australia

GISERA Director Dr Damian Barrett said that the CSIRO research conducted via GISERA in this region was an Australian first and provided unique insights into the impacts of hydraulic fracturing in Australia.

"This new research provides valuable data about hydraulic fracturing in coal seam gas formations in the Surat Basin, Queensland," Damian said. "Previously, the only information about hydraulic fracturing was from overseas studies in quite different shale gas formations.

"Clearly governance, industry regulation and operational integrity are crucial in managing risk and potential impacts of hydraulic fracturing."

Results from the studies showed:

- Air quality monitoring found hydraulic fracturing operations had little to no impacts on air quality, with no significant variation between air quality at hydraulic fracturing operational sites and control sites where no hydraulic fracturing activities occurred.
- Levels of most atmospheric air pollutants detected were generally below relevant national air quality objectives. Increased levels of airborne particles were associated with dust from vehicle movement.
- Hydraulic fracturing chemicals were not detected in water samples taken from nearby groundwater bores, soil samples from sites adjacent to operational wells, or in water samples from a nearby creek.
- Water produced from the wells immediately after fracturing contained hydraulic fracturing chemicals, elevated concentrations of major ions (salts), ammonia, organic carbon, some metals and organic compounds, with concentrations reducing to a pre-fractured state within 40 days.
- Current water treatment operations are effective in removing hydraulic fracturing chemicals and geogenic chemicals either completely or reducing levels to within acceptable limits according to water quality guidelines.
- Some types of biocides used in hydraulic fracturing fluids and some geogenic chemicals were completely degraded in soil samples within two to three days.
- Soil microbial activity was reduced by the addition of hydraulic fracturing fluids and produced water.

The three year research program comprised two phases – review, design and test best-practice sampling and monitoring techniques and methods; and an extensive field-based monitoring and sampling program for air, water and soils, and a laboratory analysis of soil samples exposed to HF chemicals.

The study team included researchers from CSIRO, the

The study included researchers from CSIRO, ANSTO, Macquarie University and The University of Queensland.

COLLABORATIVE RESEARCH

GISERA is a collaboration between CSIRO, Commonwealth and state governments and industry established to undertake publicly reported independent research.

The purpose of GISERA is for CSIRO to provide quality assured scientific research and information to communities living in gas development regions focusing on social and environmental topics.

Australian Nuclear Science and Technology Organisation (ANSTO), Macquarie University and The University of Queensland.

Australia Pacific LNG's upstream operator, Origin Energy, provided researchers with access to production wells and HF operations during the research period.

What is hydraulic fracturing?

HF is a stimulation process used to increase the flow of gas and water from a gas well. It involves the high pressure injection of fluids and solids into a well, to fracture the coal seam and open pathways for gas and fluids to flow back into the well and to the surface.

What are HF fluids?

HF fluids are typically 90–91 per cent water, seven to eight per cent proppants (solids, like sand) and around one to two per cent chemical additives. The proppants help keep the fractures open for gas and fluids to flow into the well. The chemical additives are used for:

- Water conditioning (biocides) to control microbial growth and pH;
- Preventing the swelling or migration of clays into the fluid stream;
- Inhibiting corrosion of well casings and equipment; and,
- Managing the viscosity of the fluids – ensuring the proppant remains in suspension.

What is flowback water?

Following HF, the coal seam is depressurised and a mixture of formation water and HF fluids flow back to the surface through the well. Flowback waters contain HF fluids used (water, proppant and chemical additives), in addition to naturally occurring (geogenic) chemicals that have been mobilised from the coal seam during the HF process.

Flowback waters are stored and transported according to Queensland Government regulations and treated at a licenced waste treatment facility.

What is produced water?

Produced water is the water that is extracted from the well under normal operating conditions. Produced water is transported by pipelines for storage and treatment via reverse osmosis technology prior to beneficial re-use.

Current water treatment operations are effective in removing geogenic and HF chemicals either completely or reducing levels to within acceptable water quality guideline limits. Following treatment, around 80 per cent of produced water is available for beneficial use, such a crop irrigation or aquifer re-injection.

Air quality

Potential sources of air pollutants associated with HF include the proppant, HF chemicals, flowback fluids, coal seam gas and vehicles/equipment on site. In the air quality study continuous measurements were undertaken for common pollutant gases and airborne particle concentrations at two sites. In the laboratory over 1000 gas samples collected across 13 sites were analysed for up to 45 different pollutants along with concentrations of 25 chemicals present in 180 samples of airborne particles collected across six sites.

The ambient air quality measurement program had three main objectives:

1. Compare air quality at a HF site with non-HF sites, and with Australian state and federal air quality objectives.
2. Quantify changes in air pollutant levels during HF operations.
3. Identify the contribution of HF and non-HF sources of air pollutants at the study site.

Key results

- The levels of most air pollutants were well below relevant air quality objectives for the majority of the study period.
- Occasional high airborne particle concentrations were observed that exceeded national air quality objectives, but similar events were also observed at sites not impacted by HF activities.
- Dust associated with the movement of heavy vehicles and equipment on site was the dominant source of airborne particles during exceedance events.
- Emissions from diesel-powered vehicles and equipment on site during well development contributed to small increases (above background levels) in NO_2, CO, PM2.5, formaldehyde, BTX and PAHs but were still well within relevant ambient air quality objectives.
- The dominant sources of air pollutants in the background atmosphere were fires, regional transport of pollutants from industry and agriculture, secondary production in the atmosphere, and natural sources, such as soil, and fungi and biota in the soil.

Water and soil quality

The water and soil quality study aimed to:

1. Quantify the impacts of HF operations on nearby surface water, groundwater and soils.
2. Assess concentrations of any HF chemicals and geogenic chemicals in flowback and produced waters.
3. Compare water quality in sampled waters with relevant Australian water guidelines.

The water quality study collected samples from creek waters, groundwater, flowback water, produced water, samples of HF fluid, and soil cores from well pads. A total of 113 water samples and 40 soil samples were collected, and subjected to 22 analytical procedures to determine the concentration of over 150 chemicals including organics, inorganics and radionuclides.

Key results

- No HF chemicals were detected in soil samples, groundwater samples or samples from a local creek.
- Water produced from the wells immediately after HF contained HF chemicals, elevated concentrations of major ions (salts), ammonia, organic carbon, some metals and organic compounds, with concentrations reducing over time.
- At all monitored CSG wells the impacts of HF activities on water quality diminished over time.
- Within 20 to 40 days of completion of HF operations, concentrations of the majority of HF chemicals reduced to below detectable limits.
- Within 20 to 40 days of completion of HF operations, concentrations of geogenic chemicals returned to levels assumed to reflect coal seam formation water (i.e. returned to a pre-fractured state).
- In line with Government regulation industry have monitoring systems and processes in place to prevent flowback water and produced water from entering groundwater or surface waterways.
- Current water treatment operations are effective in removing geogenic chemicals and compounds and HF chemicals either completely or reducing levels to within acceptable water quality guideline limits.

More information:
Read the air, water and soils reports: *https://gisera.csiro.au/project/air-water-and-soil- impacts-of-hydraulic-fracturing-phase-2/*
Review all GISERA research in Queensland: *https://gisera.csiro.au/project/states/qld*

NORTHERN FOCUS
COVERING NORTHERN NSW & QUEENSLAND

Fear of frost trumps yield loss from heat stress

PLANTING date is still one of the most cost-effective tools to help Queensland and New South Wales grain growers bolster crop yield potential by better managing both frost and heat stress during the grain-fill period.

Research conducted by AMPS under a Grains Research and Development Corporation (GRDC) investment has reaffirmed the benefits of early planting from a production and economic point of view but additionally, has assessed the effect of elevation on frost risk and implications for sowing strategies.

AMPS Agribusiness research manager Matt Gardner said the trial work found that there were drastic changes in frost risk with only small changes in elevation (20–50 metres) which presented significant opportunities to push planting dates forward without necessarily increasing frost risk.

Planting date has greatest impact

"Over the years there've been plenty of trials establishing the benefits of early sowing. But if I stand in a room of growers, typically every person could name a year where they've been badly frosted but very few could probably quantify how much yield they've lost to heat stress over those years," Matt said.

"So, growers generally take a conservative approach to planting date because the fear of frost damage influences their decisions to a greater extent than the often intangible yield loss from heat stress during grain fill.

AMPS Agribusiness research manager Matt Gardner.

"But of all the major agronomic management levers that can be manipulated to achieve yield potentials, planting date can have the greatest impact and is one of the few management tools that can be changed with negligible additional costs to the grower."

Elevation gives frost protection

The trial work demonstrated the value of elevation in protecting crop yield, highlighting opportunities to plant earlier in higher parts of the landscape without necessarily increasing frost risk.

For example, on the Liverpool Plains (NSW), a late April planting date created an additional $425 per hectare and $1155 per hectare net return compared with mid-May and early June planting dates respectively at the top of the slope over a three-year period. This was calculated on a wheat price of $250 per tonne.

Even in 2016 when spring conditions were ideal, there was

There are huge differences across any given cropping landscape, and this needs to be exploited for better frost management.

still a 1.34 tonnes per hectare yield penalty for delaying planting dates from late April to early June.

At the same time, the work found that the risk of heat stress during grain fill remained relatively consistent with temperatures being similar for top and bottom slope sites, narrowing the window for optimum conditions for flowering crops.

The other significant part of the trial work has been focussed on the impact of higher and lower elevations on crop development.

It found that lower points in the landscape have more frost events with greater duration compared to higher elevations, according to Matt.

"Lower minimum temperatures and a greater number of frost events in lower parts of the landscape reduce the accumulation of growing degree days and hence delay crop development.

"But despite the delayed development, there is still a need to adjust planting date to achieve an acceptable level of frost and heat risk during grain fill.

"There are huge differences in frost risk across the landscape and this needs to be exploited. There are very few single management changes that will deliver these type of returns."

Accurately determine frost risk

The challenge for growers and agronomists lies in accurately determining frost risk and therefore a planting strategy when data and models rely on weather stations that can be located some distance away from individual paddocks or farms.

"Growers and agronomists rely heavily on previous experience, local weather station data, sowing guides and predictive models such as CliMate or APSIM to determine planting dates but it can be challenging when the nearest weather station is located some distance away from paddocks or farms," Matt said.

"Data from the trial work could be used in models to assist growers to better predict frost risk and planting dates across the landscape rather than simply near the closest weather station.

"Temperature loggers have been used in our trials and we've found growers are using them on an individual farm and regionalised level to help with decision making on variety selection and sowing date."

Commercial application

Liverpool Plains grower Tom Simson is one of many who has adopted the trial work on a commercial level.

Since seeing the trial work Tom has started collecting temperature data across his farm near Premer and now has over five years' worth of information.

"Being able to record on farm temperature has meant we have been able to refine that optimum sowing window," Tom said. "With the help of Matt and the research trial work I have been able to confidently bring my sowing date forward by as much as six weeks.

"With the change in sowing date and variety choice I can confidently say we are seeing an average yield increase of 1.2 tonnes per hectare.

"In 2018 I was able to make a commercial decision regarding planting dryland Lancer. I was only able to make that decision because of the trials and data sets that had been presented to me by AMPS Research.

"Thanks to that I planted dryland Lancer on May 10 which yielded 3.3 tonnes per hectare. Historically we would have missed that sowing opportunity as we would have thought it was too early."

For further information on the trial work, download a copy of Matt's recent GRDC Grains Research Update paper *Can we refine planting dates further?* from the GRDC website *www.grdc.com.au* ■

Water stress reduces glyphosate efficacy on key weeds

By Bhagirath S Chauhan[1]

AT A GLANCE:

- Awnless barnyard grass (BYG) and windmill grass (WMG) have developed glyphosate-resistant populations in the northern region of Australia.
- Understanding how glyphosate efficacy reduces is important.
- Environmental stressors such as drought can affect the efficacy of glyphosate.
- Glyphosate efficacy on both weeds species was significantly reduced by water stress.

AWNLESS barnyard grass (BYG) and windmill grass (WMG) are both troublesome weeds in Australian summer cropping systems due to their highly-competitive nature and adaptability to varied environmental conditions. Each BYG plant can produce over 40,000 seeds. Similarly, WMG is capable of producing thousands of seeds per plant. Both species have developed glyphosate-resistant populations.

Glyphosate efficacy can be affected by several factors, including soil moisture. The effect of environmental conditions on both the growth of weeds as well as the properties of herbicides before, during and after application is an important area of research for the future. Climate trends of drought and highly-variable rainfall are complicating factors in the efficacy of glyphosate and the development of glyphosate resistance in weed populations. The very same responses weed plants make to adapt to drought, also result in increased herbicide resistance.

Separate pot studies were conducted to evaluate the efficacy of glyphosate on BYG and WMG when applied in different soil moisture conditions.

How we did the research

The seeds of glyphosate-resistant and glyphosate-susceptible BYG and WMG were collected from different fields in Queensland. The resistance and susceptible status of both weeds was confirmed before the experiments were conducted at the QAAFI Weed Science screen-house facility of The University of Queensland, Gatton in 2017–18.

Bhagirath S Chauhan.

Seeds were grown in pots and thinned to one plant per pot after emergence. Plants were grown at two soil moisture levels: Well-watered and water-stressed. Well-watered treatments were watered daily but the other half received no irrigation for the two weeks preceding glyphosate spraying.

At the three to four leaf stage, plants were sprayed with Roundup Ultra Max 570 (Glyphosate570, hereafter) at 0, 315, 630, 1260, and 2520 ml per hectare. Glyphosate570 was applied using a Research Track Sprayer at a spray solution of 108 L per hectare.

Plants were not watered until 24 hours after spray. After that, regardless of water regime, all pots were irrigated daily.

Each treatment was replicated eight times.

Plant survival was determined two weeks after spraying and surviving plants were harvested and dried for three days in an oven at 70°C before dry matter was measured.

What we found

Barnyard grass

The efficacy of Glyphosate570 was significantly reduced by water stress in all treatments. While no glyphosate-susceptible weeds survived at the two highest herbicide rates under well-watered conditions (Figure 1), between 8 and 38 per cent of weed biomass was still produced under water-stressed conditions

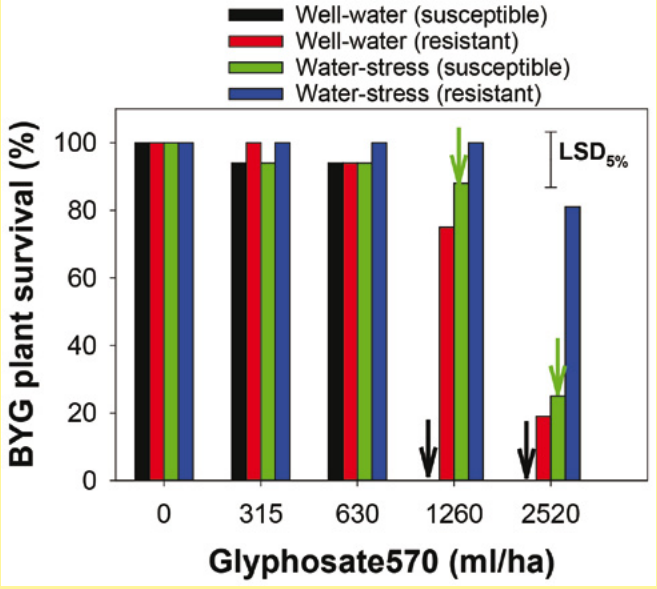
Each barnyard grass plant can produce over 40,000 seeds.

Windmill grass is also a prolific seeder.

(Figure 2). These results suggest that glyphosate application on water-stressed plants may make control of glyphosate-susceptible plants difficult.

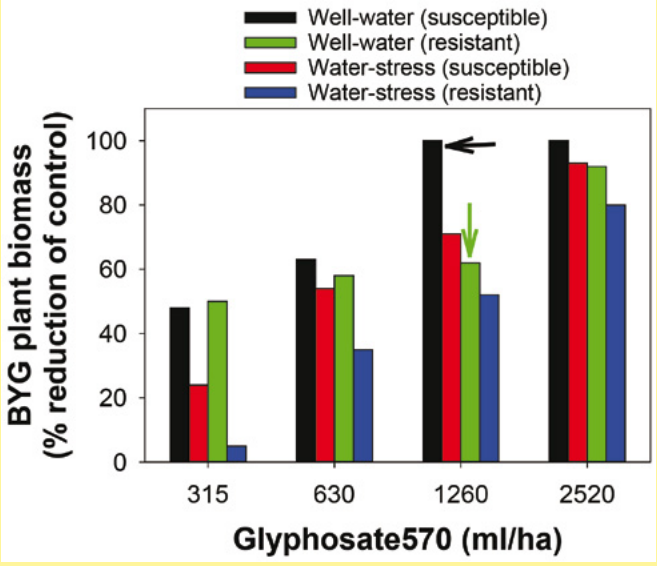
In the glyphosate-resistant population, 81 per cent of plants survived under water stress at twice the recommended rate of Glyphosate570 compared to only 19 per cent in the well-watered treatment (Figures 1 and 2).

FIGURE 1: The effect of Glyphosate570 rates and soil moisture (well-water and water-stress) on plant survival of the glyphosate-resistant and glyphosate-susceptible biotypes of BYG



The black and green arrows show the difference in plant survival of the susceptible population between well-water and water-stress conditions.

FIGURE 2: The effect of Glyphosate570 rates and soil moisture (well-water and water-stress) on plant biomass (% reduction of the control treatment) of the glyphosate-resistant and glyphosate-susceptible biotypes of BYG



The black and green arrows show the difference in plant biomass reduction of the susceptible population between well-water and water-stress conditions.

Windmill grass

The impact of water stress on glyphosate efficacy was significant, particularly in the glyphosate-susceptible population.

No glyphosate-susceptible plants survived the application of Glyphosate570 at 630 ml per hectare or more under well-watered conditions (data not shown). But glyphosate-susceptible plants survived at all herbicide rates in water-stressed conditions.

A similar trend was observed for WMG plant biomass (Figure 3). There was also 100 per cent survival in all glyphosate-resistant plants, whether well-watered or water-stressed.

To sum up

Results show the clear implications of rainfall variability and drought on glyphosate efficacy. Across both weed species, water stress impacted the effectiveness of glyphosate in both herbicide-resistant and herbicide-susceptible populations.

The effect of drought-stress conditions even allowed for the survival of all herbicide-susceptible WMG populations across all glyphosate application rates. This was in comparison to no WMG plant survival beyond the lowest spray rate under well-watered conditions. Significant changes in survival rates were also seen in both glyphosate-susceptible and glyphosate-resistant BYG populations.

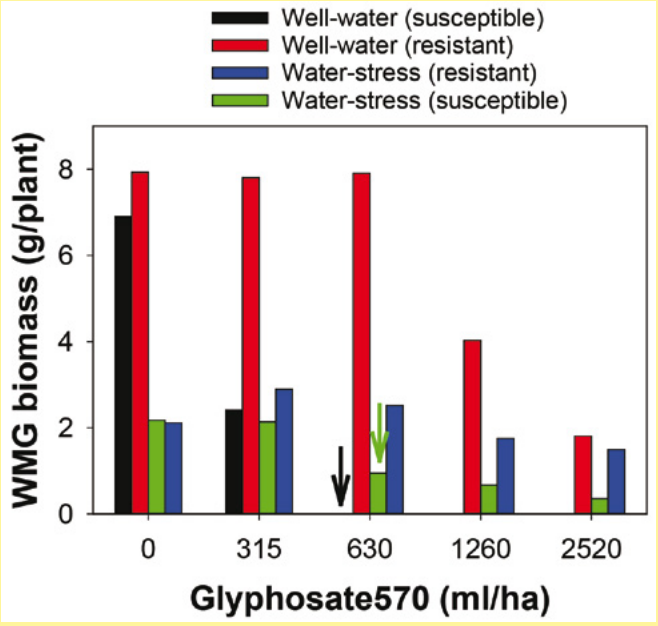
These results under drought-stress conditions highlight the importance of herbicide application conditions. Spraying weeds before they reach the stage of being affected by water-stress will impact the efficacy of glyphosate and will also serve to reduce the potential for further development of glyphosate resistance in future.

An understanding of how weeds adapt to these changing conditions will help shape future weed management strategies.

1. The University of Queensland, Gatton, Queensland 4343.

For detailed methodology and results of this research, please see Mollaee et al., 2020, Scientific Reports (BYG) and Weller et al., 2019, Scientific Reports (WMG). ■

FIGURE 3: The effect of Glyphosate570 rates and soil moisture (well-water and water-stress) on plant biomass of the glyphosate-resistant and glyphosate-susceptible biotypes of WMG



The black and green arrows show the difference in plant biomass of the susceptible population between well-water and water-stress conditions.

Science helps farms adapt to drought

By the Queensland Alliance for Agriculture and Food Innovation

A NEW crop is making its way onto Australian farms as more severe drought causes a rethink of the crops best suited for cultivation in the northern growing region. The advent of more frequent and severe droughts has hit a critical juncture for agriculture – the point where farmers need to consider swapping out of standard staple crops because they are insufficiently drought resilient.

Already in parts of India, popular maize crops have been replaced by drought tolerant sorghum.

A similar adaptation strategy is now underway to help farmers in Queensland and northern New South Wales deal with shortfalls in summer rainfall needed to successfully cultivate mungbeans, soybeans or peanut.

Introducing pigeonpea

The solution? Introduce the drought-hardy legume, pigeonpea (*Cajanus cajan*), a protein-rich crop that is vital to the survival of resource-poor farmers in the semiarid tropics of Asia and Africa.

This strategy retains the soil benefits obtained from the inclusion of a legume in a farm's crop rotation. Concurrently, farmers benefit from a much-needed boost in the cropping options available to them, especially for more marginal seasons.

RCN Rachaputi checks a pigeonpea crop trial at The University of Queensland Gatton campus.

This timely innovation is the work of Associate Professor RCN Rachaputi (nickname 'RCN'), a legume crop physiologist based at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at The University of Queensland Gatton campus.

In 2019, RCN launched a pigeonpea-breeding program that aims to produce a high yielding variety adapted to Australian growing conditions within about four years.

This work is funded exclusively by an industry partner capable of processing and marketing Australian-grown pigeonpea – an essential pre-requisite for growers to adopt the new crop.

"We performed a feasibility study leading up to this project that found pigeonpea – with its high levels of drought and heat tolerance – is a viable option for the northern grain growing region," RCN says.

"We found that pigeonpea outperforms mungbeans no matter the environment, a finding that has created a lot of industry interest, including requests for seed from growers."

Potential for world best yields

Yields possible on Australian farms are likely to be among the best in the world, with four tonnes of pigeonpea per hectare achieved in Queensland under non-limited conditions and at optimal row-spacings.

This compares favourably with the two tonnes per hectare achieved by growth in research plots in other parts of the world.

In India, where the crop was originally domesticated more than 3500 years ago, current average yields of pigeonpea are just 0.9 tonnes per hectare, reflecting heavy losses due to a single pest – Helicoverpa pod borer, a moth that can also devastate cotton crops.

RCN Rachaputi with senior research officer Dr Solomon Seyoum inspecting the growth of pigeonpea crop trial at UQ Gatton campus.

Ingenious pest management

Anticipating the adverse impacts of this pest to Australian growers, RCN is taking an ingenious and largely unprecedented approach to provide Australian varieties with in-built genetic resistance to certain pests.

His approach involves screening Australian native species that are wild relatives to cultivated pigeonpea for the needed pest resistance genes.

"Wild pigeonpea proliferates across the northern section of Australia making this region one of three globally significant centres for pigeonpea biodiversity," RCN says.

"My team has been characterising this biodiversity and we have identified species that are 100 per cent resistant to Helicoverpa.

"Now my challenge is to work up a way to transfer those wild genes into the cultivated lines."

Productivity traits

The breeding program is also selecting for important productivity characteristics, especially:

- Reducing the height of pigeonpea from about three metres to a machine-harvestable 0.5 metres;
- Increasing seed size by 30 per cent and changing seed colour to white or red; and,
- Earlier maturity by developing varieties that are insensitive to changes in day length.

None of these breeding goals are trivial and RCN admits that a three-year timeframe is unrealistic if he was restricted to traditional breeding technology. In that case, 15 years would be more realistic.

Instead, he is using the most advanced breeding technology available anywhere in the world.

Speed breeding

Included is Gatton's new speed breeding facility, a high-tech glasshouse that uses artificial light to induce plants to flower faster, which makes it possible to grow four generations of pigeonpea in one year.

Additional acceleration is possible by the development of algorithms that can simulate impacts of pigeonpea biodiversity on growth rates, flowering time, yield and impact on yields of Australian growing conditions.

These algorithms form a new module in the highly advanced APSIM plant crop growth model that can simulate years of breeding field trials in months, thereby providing a rapid way to select the highest performing lines and breeding strategies.

"APSIM modelling can account for the complex way that genetics, agronomy and environment interact to affect yields, making this tool highly realistic and predictive for breeding outcomes," RCN says.

"That means we can accelerate the delivery of a much needed new option for our cropping systems that are in real need for another broadleaf legume. From what I have seen to date, I think the new pigeonpea variety under development will fill that role."

More information: Associate Professor RCN Rachaputi, Principal Research Fellow, Centre for Crop Science, QAFFI, Gatton. E. rao.rachaputi@uq.edu.au ■

Coordination the key to cotton in northern Australia

THE immense opportunity to develop a viable and sustainable cotton industry in northern Australia will only be realised through an approach tailored to the region's tropical environment and coordinated pest and disease management.

That's according to 2018 Nuffield Scholar Luke McKay who, with support from Cotton Australia and Cotton Research and Development Corporation (CRDC), visited farms and businesses across 12 countries researching ways to optimise cotton production in variable climatic conditions.

"During my travels, I sought to develop a blueprint for the cotton industry in northern Australia, but through various meetings with Brazilian farmers, agronomists and researchers, it became clear that a rigid year-on-year production plan in these climatic conditions doesn't exist," Luke said.

Changed growth and management in the tropics

Luke outlines several factors that impact cotton production in tropical climates, and the role management plays in adapting to changing growth habits of cotton in the extremities of rain, cloud, humidity, and temperature that occur in northern Australia.

In the report, he reveals that responsibility doesn't stop at the farm gate, with all growers playing a role in area-wide management for pest, disease and resistance mitigation.

"Northern Australia has a climate that will allow cotton to grow year-round, but when growing occurs for too many months, significant pressure is placed on pest and resistance management," Luke said.

"Poor crop destruction increases the risk of pests persisting through to the following season, placing immediate pressure on the next crop.

"This was evident during my travels in Brazil where I witnessed the impact boll weevil was having on the cotton industry, with one farmer averaging 18 sprays across the farm.

"Compare this to the US cotton industry, which has successfully eradicated boll weevil through an industry-wide and ongoing eradication program.

"US farmers were adamant that whole industry buy-in for this program was the key to successfully achieving a sustainable and coordinated approach to pest management.

"While boll weevil is not present in Australia, the lesson for cotton production in the north is the benefit that coordinated area-wide management can have on the cotton industry."

When looking at factors that would impact the viability and success of cotton production in northern Australia, Luke concludes that a holistic approach which assesses major crop indicators, varying climatic influences and uses area wide management systems is necessary.

"To manage evolving scenarios with changing conditions, managers must be constantly assessing the crop and adapting in-crop management methods to ensure sustainability," Luke said.

"Production plans must also be flexible enough to incorporate the seasonal variability typical to the north.

"If all stakeholders acknowledge the risks, develop and adhere to best management practice and manage the variables within their control for the betterment of the entire industry, there are great opportunities to develop a productive and profitable cotton industry in northern Australia," Luke concluded.

Contact details: Northern Ag Management, 107 Kestrel Place, Kununurra, WA, 6743. Phone: 0488 733 358, Email: luke@northernagmanagement.com.au ■

2018 Nuffield Scholar Luke McKay believes industry-wide adoption of best management tropical agriculture practices will be needed for cotton to be a success in northern Australia.

Lifting sorghum protein content and digestibility

By Larissa Mullot, Agricultural Biotechnology Council of Australia

RESEARCHERS from the Queensland Alliance for Agriculture and Food Innovation have announced a major breakthrough in lifting the protein content of sorghum using gene editing. The research team has improved the digestibility of the crop and boosted sorghum protein levels to 15 to 16 per cent – up from the usual nine to 10 per cent.

Professor Ian Godwin explored the research and its potential to reduce costs for feedlot industries and increase demand for Australian sorghum at the TropAg conference in Brisbane in November, 2019. For example, the increased protein is expected to deliver a 50 cent per head reduction in the cost of producing a two-kg meat bird.

"The genes of the sorghum plant have been edited to unlock the digestibility level of the available protein," Ian says.

"Gene editing has enabled us to knock out some of the existing genes, increasing the digestibility of the crop.

"The breakthrough is also expected to generate big interest in the 46 Sub-Saharan African countries, where an estimated 500 million people rely on sorghum as a food source."

The International Crops Research Institute for the Semi-Arid Tropics describes sorghum as a highly reliable crop that grows well in hot, dry environments. It is "climate change-ready" and provides food security and income for millions of low-income farmers.

Being developed in partnership with GRDC and a seed company, the new high protein digestible sorghum has been put to the test in field conditions at the University of Queensland's St Lucia Campus in Brisbane – and further evaluation work is planned in the US.

The Agricultural Biotechnology Council of Australia (ABCA) is an industry initiative established to increase public awareness of, and encourage informed debate and decision-making about, gene technology. ■

Queensland Alliance for Agriculture and Food Innovation (QAAFI) Centre Director for Crop Sciences, Ian Godwin and his research team have significantly boosted protein levels in sorghum. (PHOTO: QAAFI)

IPM IN A COVID-19 WORLD: AN AGRONOMIST REFLECTS

The diversity of insect life in a cotton crop must be judged harshly. Are you a pest or are you a beneficial? It's discrimination at it's worst .

A pest lives as though on death row. Overstep the threshold and life is over. An anxious life is led, constantly attempting to avoid detection from the prying eyes of the vigilant agronomist. Well versed in social distancing, pests know full well the consequence of gathering in large numbers.

Two per square metre hardly seems a party, but for mirids that's enough to bring on the heavy artillery.

Spilt honey dew from an all-night mealy bug binge can result in a rush to get affairs in order before the Cryptolaemus release.

Heliothis don't stand a chance against the triple genes of GM. Each generation desperate to develop a vaccine but with only 42 days and little funding, the task is overwhelming. Quarantine is offered to the privileged few in the safe harbour of the pigeonpea.

As for the self-indulgent aphids and spider mite suffering destination envy and unable to resist the lure of the latest hot spot, their fate is all but sealed.

The heavy lifting of saving the ecosystem falls to the beneficials. Lacewing, ladybird, shield bug, thrips, big eyed bug and many more all work with a common goal.

Not wanting to see their world ruined by consumerist pest behaviour, they hunt and chew and pierce with the determination of a Thunberg army.

Beneficials work with militant fervour to curtail Pest numbers. Ever hopeful that their efforts will prevent the arrival of the pesticide spray – the ominous cloud of disruption.

To watch, guide, encourage and cheer this entomological interaction below the surface of a cotton crop, is to realise that the insects have their very own environmental battle for a precariously balanced life.

Graham Volck, Agronomist, Emerald, Queensland

SOUTHERN AUSTRALIA FOCUS

COVERING CROPPING SYSTEMS OF SOUTHERN NSW, VICTORIA, TASMANIA, SOUTH AUSTRALIA & WESTERN AUSTRALIA

AHRI **insight...**

The reality of spontaneous mutation

Remember the Teenage Mutant Ninja Turtles? Four baby turtles get covered in glowing green goo and a mutation takes place, changing them forever. Their parents were apparently regular turtles and the mutation that gave Leonardo, Donatello, Michaelangelo and Raphael human characteristics and amazing crime-solving and ninja fighting skills, was the result of an external influence on their DNA.

This is a pretty cool illustration of what is known scientifically as 'de novo' (Latin meaning 'from new') mutation.

Cowabunga dude!

NOT surprisingly, de novo mutations are quite rare in the real world – but even rare things can happen if the population is large enough.

When it comes to the evolution of herbicide resistance, there are two biological pathways:

- The first is simply natural selection where a small number of the population can withstand a particular stress (e.g. herbicide), they set seed and eventually their progeny are the majority, and they generally thrive. Resistant alleles may prolificate at the site of selection (i.e. due to frequent and regular use of a particular herbicide at that site) or they might be imported from another site of selection as seed or pollen.
- The second is 'de novo mutations' where the parent plants are both susceptible to the herbicide but a spontaneous mutation in the genes of the progeny renders it (and its progeny) resistant. Resistance that arises this way is very rare and often comes with a 'fitness penalty'.

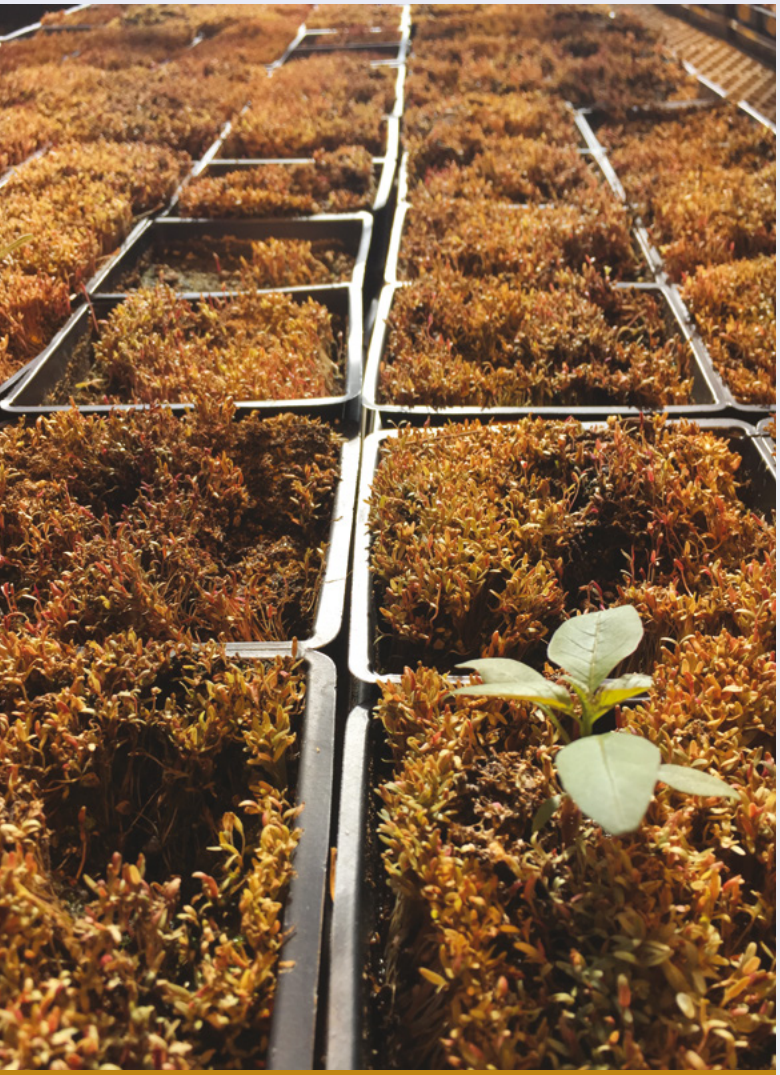
You might ask "Why does it matter? The fact that the weed population is resistant is what matters, not how it happened."

The driving force behind this research was the lack of empirical data on de novo mutation in plants and the need for this data to improve the reliability of computer models that are used to test

weed management scenarios. This is the first published paper to provide empirical data on the rate of de novo mutation for herbicide resistance in plant populations.

Researchers Federico Casale, Darci Giacomini and Patrick Tranel from the University of Illinois, Urbana, Illinois, US set out to determine the likelihood of de novo mutation conferring herbicide resistance in a natural plant population and whether sub-lethal doses of herbicide increases the rate of de novo mutation.

Grain amaranth seed (in spoon) is easily distinguished from weedy amaranth seed.



Mutation screening of grain amaranth (the healthy plant turned out to be a contaminant).

Using grain amaranth (*Amaranthus hypochondriacus L.*) as the test case, the researchers screened 70.8 million plants looking for spontaneous herbicide-resistance to acetolactate synthase (ALS)-inhibiting herbicides.

Through the screening of this large susceptible population they detected no spontaneous resistant genotypes. This suggests that the probability of finding a spontaneous ALS-resistant mutant in a given sensitive population is lower than 1.4×10^{-8}.

This empirically determined upper limit is lower than expected from theoretical calculations based on previous studies. In these earlier studies, the rate of spontaneous mutations to resistance to ALS-inhibiting herbicides was estimated at 1×10^{-9} in *Arabidopsis thaliana* and at about 2.7×10^{-8} in *Nicotiana tabacum* cell cultures.

Mutation rate assumptions in weed simulations

Computer weed simulation models are a useful way to test the likely outcome of different weed management scenarios. Like all computer models, weed behaviour models have many assumptions built into them and these assumptions influence the results. Computer modellers obviously go to great lengths to ensure that the assumptions are as realistic as possible, but some assumptions are more difficult to test than others.

Herbicide resistance models include assumptions about the rate of selection for resistant mutants in the standing population, the potential flow of resistant alleles and the spontaneous mutation rate of the target weed. The rate of selection within a genetically diverse population is widely studied and excellent empirical data exists to use in computer modelling.

For example, Steve Powles and Chris Preston, published work in 2002 that measured the frequency of ALS-inhibitor resistance in unselected populations of rigid ryegrass (*Lolium rigidum Gaudin*) in Australia. Their work showed that herbicide resistance occurred through selection for resistant alleles already present in the standing population. This rate of resistance to ALS herbicides in an unselected standing population of ryegrass is in the order of 10^{-5} to 10^{-4}.

On the other hand, the rate of de novo mutation is harder to study and, until now, there was no empirical data available, so the assumptions related to spontaneous mutation have been less robust.

This research has started to help fill that knowledge gap and suggests that the rate of de novo mutation might be less than previously thought.

Why work with grain amaranth rather than a weed species?

The researchers chose grain amaranth because it does not have known herbicide resistance in its genetic background. This makes it a good candidate for de novo resistance studies.

Grain amaranth seed is pale in colour and easy to distinguish from its weedy counterparts, reducing the chance of contamination in the study. Each mother plant produces a large quantity of genetically homogeneous seed with reduced seed dormancy. These characteristics combined to give a plant population that germinated evenly and rapidly, allowing uniform exposure of seedlings to soil-applied herbicide selection.

Why study ALS-inhibiting herbicides?

Resistance to ALS-inhibiting herbicides is common. There are at least 29 different amino acid substitutions, distributed

across eight amino acid sites that have been reported to confer resistance to ALS-inhibiting herbicides in plants.

ALS-inhibiting herbicide was chosen for this research because resistant mutations are functionally dominant at normal herbicide application rates. This enables the selection of spontaneous mutations in the first generation when they may be present only in one chromosome.

The researchers calculated that the probability of any given grain amaranth plant spontaneously mutating to be resistant is 7.9×10^{-8}, based on genomic studies of the 'model higher plant' *Arabidopsis thaliana*. This suggests that screening at least 38 million plants would be expected to generate at least one spontaneously resistant plant.

To be safe, the Illinois researchers screened 70.8 million plants – even so, no spontaneously resistant plant was found.

Does herbicide treatment increase the rate of resistance?

The question arises "Does exposure of weeds to sub-lethal herbicide rates increase the chance of new genetic variants that confer resistance arising?"

Sub-lethal dosing is common in field situations such as along paddock borders and where the crop canopy or stubble might intercept some of the applied herbicide. Since herbicides cause obvious stress on plants, some researchers have proposed that this stress (sub-lethal dosing) may select for, or induce, mutator activity within genomes.

In the second part of the study, plants were treated with one of two sub-lethal rates of atrazine (0.1 and 0.2 kg per hectare).

The plants showed clear symptoms of herbicide injury and the higher herbicide rate caused more severe symptoms, but the plants survived the treatment and produced a similar number of seeds as the control group.

More than 11 million seedlings derived from these atrazine-treated parental plants were then screened for ALS-inhibitor resistance.

Again, no spontaneously resistant mutants were found.

The researchers acknowledge that there are several reasons why no resistant mutants were found, but in this study they found no evidence to suggest that sub-lethal herbicide exposure of the parents generated resistant offspring.

What are the implications for weed management?

Although this study suggests that the rate of spontaneous mutation providing herbicide resistance might be lower than previously thought, it is still a real possibility, and possibly more so in weed populations.

Even so, growers and agronomists can be sure that herbicide resistance is far more likely to arise from the standing genetic variation in weed populations than from spontaneous mutation, even in response to sub-lethal herbicide application.

Resistant alleles can exist prior to the selection (herbicide use), having been conserved in the weed population for years. They must have little to no fitness cost and these mutations can be expected to remain in the population even if the herbicide is no longer used.

This paper represents a starting point to further evaluate the rate of spontaneous herbicide resistance in weed species and to further firm up the assumptions that underpin computer modelling for weed management.

For more information: Australian Herbicide Resistance Initiative
www.ahri.uwa.edu.au ■

Seed from grain amaranth plants treated with sub-lethal doses of atrazine went on to produce a similar quantity of seed as the control group (no herbicide).

Early-sown canola may escape blackleg clutches

CANOLA crops sown early in warm conditions may escape potentially severe blackleg disease during the growing season. Many crops have been sown earlier than usual this year following decent summer and early autumn rains.

Marcroft Grains Pathology principal Steve Marcroft – who is co-ordinator of the Grains Research and Development Corporation's (GRDC) National Canola Pathology Program investment – says crops sown before April 30 into warm conditions that allowed them to quickly progress through the seedling growth stage are at the lowest risk of developing blackleg.

"Crops sown from May onwards are likely to face more disease pressure from blackleg, with crops sown from June onwards at the highest risk."

Steve Marcroft. (PHOTO: N Baxter)

Updated ratings

This advice is contained in the GRDC *Blackleg Management Guide* autumn 2020 edition which also features the latest blackleg ratings for canola cultivars.

Steve says results from the latest blackleg screenings of canola cultivars have been factored into the updated ratings for 2020. Blackleg ratings can change from year-to-year if the fungus overcomes cultivar resistance.

Leptosphaeria maculans, the causal agent of blackleg disease, is a sexually reproducing pathogen that may overcome cultivar resistance genes. Fungal spores are released from canola stubble and spread extensively via wind and rain splash. The impact is more severe in areas of intensive canola production.

Blackleg in canola. (PHOTO: Steve Marcroft)

"Blackleg can cause severe yield loss, but can be successfully managed," Steve says. "Growers are advised to closely follow the recommended strategies for reducing the risk of disease which are contained in the GRDC *Blackleg Management Guide*."

The guide can be used by growers to determine whether they are in a high-risk situation and the best management practices to reduce or prevent yield loss from blackleg.

The guide also emphasises that fungicides will only provide an economic return if a crop is at high risk of yield loss.

"Fungicides complement other management practices," Steve advises. "Growers should never rely solely on fungicides to control disease as this poses a high risk for development of resistance."

Management app also updated

The *BlacklegCM* management app has also been updated with the latest disease ratings. The app, a GRDC investment, provides growers with a tool that can forecast the likelihood and severity of the disease, associated yield loss and economic returns on a paddock-by-paddock basis.

Steve says the tool provides growers and advisers with "an interactive interface" to explore and compare the economic outcomes of different management strategies for blackleg, which can cause up to 90 per cent yield loss where a cultivar's blackleg resistance has been overcome.

The app, available for use on iPads and tablets via the App Store and Google Play, is an extension of the *Blackleg Management Guide* which is updated twice a year to reflect any changes in the resistance status of individual cultivars.

"BlacklegCM assists growers to manage blackleg by integrating the information provided in the *Blackleg Management Guide* and producing a predicted economic outcome," Steve says.

"It can be modified to account for some of the major factors that relate to risk of yield loss due to blackleg in a particular paddock. It allows the user to compare the likely relative profitability of different disease management strategies, including paddock selection, cultivar choice, seed dressing, banded fungicide and sprayed fungicide."

BlacklegCM factors in costs, yield benefits and grain prices to give the best case, worst case and most likely estimates of economic return. It also accounts for the major factors that influence blackleg severity and can be used during the growing season to assist with foliar fungicide application decisions.

Steve says the severity of blackleg disease in 2020 will be dependent on seasonal conditions.

To further assist growers in determining the level of risk in their area, the GRDC-supported National Variety Trials (NVT) Online website, *www.nvtonline.com.au*, provides the latest information from blackleg monitoring sites across Australia.

Comprehensive information on management of canola diseases can be found in the GRDC's Diseases of Canola and Their Management: The Back Pocket Guide, available *https://grdc.com.au/GRDC-BPG-CanolaDiseases*.

Videos featuring Steve diagnosing and explaining how to control blackleg upper canopy infection can be found at *https://bit.ly/2VHwBNZ* and *https://bit.ly/2Kk3xqs* respectively, while a podcast on upper canopy infection can be downloaded via *https://bit.ly/2KikMsb*.

Contact Steve Marcroft, Marcroft Grains Pathology M: 0409 978 941. ■

Treat soil acidity early to prevent yield decline

STRATEGIC soil testing and liming in summer and early autumn is needed to address the emerging problem of surface pH stratification and subsurface acidification in previously unaffected areas of South Australia.

More than four million hectares of land in SA is now considered prone to acidification. This is where pH has declined to critical levels, causing patchy plant growth and reduced grain yields, particularly in sensitive crops such as beans, lentils and barley.

Detecting and remediating soil acidity prior to sowing gives growers the chance to address emerging acidity concerns.

Rethink soil testing

Primary Industries and Regions SA (PIRSA) Principal Consultant for Rural Solutions, Brian Hughes, says growers and advisers need to rethink how they soil test and manage lime applications to maximise returns.

"Soil pH stratification and sub-surface acidification under no-till farming systems needs different approaches to soil testing and treatment," he says.

"Where acidification develops deeper in the soil profile, it is more difficult and costly to correct."

Brian, who is managing a collaborative project with investment from the Grains Research and Development Corporation (GRDC) which is aiming to improve the treatment of surface and sub-surface soil acidity, says checking yield maps and soil testing to depths of up to 20–30 centimetres is sometimes needed to identify acid sub-surface areas.

"Also, in a no-till system, we need to better understand how to get top-dressed lime down deeper in the soil profile because lime has a low solubility and moves slowly in undisturbed soils," he says.

No-till farming systems need different approaches to soil testing and lime application techniques.

"This type of system is commonly associated with the formation of an acid layer or 'acid throttle' in the soils which restricts root growth and crop yields, particularly in sensitive crops such as pulses."

When soil testing after liming in a no-till situation, it is useful to examine pH at 5 cm intervals (e.g. 0–5 cm, 5–10 cm, 10–15 cm) to determine where the lime has moved and the presence or not of an acid throttle.

Brian says mapping soil pH in paddocks will assist in the management of acidity as lime can be applied in areas where it is most needed.

He says variable rate spreaders are particularly effective in this situation.

Strategic tillage can be used to help get the lime further down the soil profile where applicable.

"Rainfall, soil texture, organic matter and lime quality all affect the movement of lime down the soil profile," Brian says.

The Acid Soils SA project is working towards developing new data and information regarding liming rates and mechanisms for moving lime down the profile to give growers greater confidence in making management decisions.

Trial sites are being established at 11 locations across SA where soil acidity is an emerging issue. There is also work being done to identify, develop and validate novel acidity management practices, such as lime forms, placement and incorporation methods including spading or topsoil slotting. Complementary amendments will be examined at some sites.

The project is being conducted with input from Primary Industries and Regions SA, the South Australian Department for Environment and Water, the University of Adelaide, Trengove Consulting, Penrice and AgCommunicators. ■

ACID TEST FOR USE OF NOVEL TECHNOLOGY IN TESTING LIME SOURCES

Can technology such as 'X-ray fluorescence', already used in the mining industry, be applied by grain growers to more efficiently and cost-effectively identify naturally occurring lime sources on their farms?

A new Grains Research and Development Corporation (GRDC) project aims to answer this question and to assist growers to accurately analyse on-farm sources of lime that could potentially be used to ameliorate paddocks.

Soil acidity is Western Australia's most expensive soil constraint, costing the state's agricultural industry about $500 million each year.

GRDC grower relations manager – west, Jo Wheeler, said soil acidity was commonly treated using a source of carbonate, traditionally lime, transported to farms.

"Usually sourced from the coast, traditional lime sources can be an expensive option for eastern grainbelt growers who live a long way inland and therefore have relatively high transport costs," she said.

"In recent years, some growers in this region have utilised deposits of on-farm lime found naturally in some areas of heavy loam soil types.

"Currently, analysing potential on-farm lime sources involves assessing multiple sites on the proposed area and subjecting samples to a 'fizz test' with vinegar or an acid, to determine if the soil contains carbonate.

Novel technologies are being used to more quickly and efficiently access on-farm lime sources.

Jo Wheeler.

"Promising samples are then sent for analysis to determine their neutralising values, enabling growers to understand the economic value of spreading the product on acidic paddocks."

Jo said the new project was initiated after the GRDC Kwinana East Regional Cropping Solutions Network (RCSN) group identified that growers needed a better in-paddock testing method to efficiently and accurately identify lime sources, and provide information about their quality and characteristics.

The GRDC project will be conducted by GHD, a company specialising in engineering, architecture, environmental and construction services, and include analysis of technologies including XRF – an analytical technique used to determine the elemental composition of materials.

"As part of the work, a cost-benefit analysis will compare methods of sampling and testing on-farm lime sources, and the technology will then be calibrated for use by growers," Jo said.

She said if the project was successful, growers would still need to send samples away for laboratory testing.

"But the initial on-farm sampling would be better targeted and more accurately identify sources with high neutralising value – meaning fewer samples would require further testing, reducing costs for growers.

"Laboratory testing would still be required to provide growers with a full picture of the substance, including its nutritional composition and the presence of any toxic substances."

More information about on-farm lime sources is available in a GRDC publication 'Locating and Assessing On-Farm Lime Sources', and a GRDC video and podcast.

Contact Jo Wheeler, GRDC grower relations manager – West, M: 0438 292 167, E:.jo.wheeler@grdc.com.au

Farmers ahead of the curve

By Andrew Fletcher and Chao Chen, CSIRO

DESPITE a rainfall decrease in Western Australia's wheatbelt between 1900 and 2016 – which has shifted wheat yield potential southwest by an average of 70 km – actual wheat yields have increased.

Wheat farmers are adapting to changing growing conditions.

New research published in *Climatic Change*, demonstrates the importance of research and development and the continued ability of farmers to innovate and adapt in order to keep ahead of the declining yield potential curve.

The study analysed 117 years of daily climate data using the APSIM model developed by CSIRO and partners. Climate data, including rainfall, was combined with soil type to determine yield potential at numerous points across the WA wheat belt for each of the 117 years.

Yield potential is the yield farmers could achieve given the climate and soil type and using current best practice and technologies.

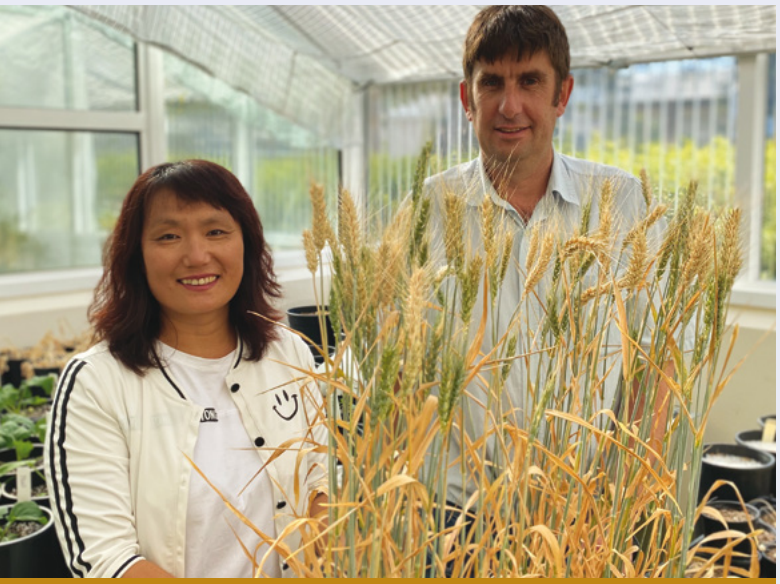
Adapting to change

The research showed that up until 2000, yields had been increasing but after that, they did not increase, and year-to-year variation increased. This is consistent with a 2017 CSIRO study showing national wheat yields had stalled since 1990, when they had previously been increasing.

To adapt to the reduced rainfall, Western Australia's farmers are employing a range of tactics, recognising that they can't keep doing what they've always done. Many are now sowing their crops earlier in the season and also dry sowing rather than waiting for autumn rain.

Without this continuous improvement in crop genetics and agronomic practice, Western Australia could well see a decrease in wheat yield associated with a changing climate.

The impacts of a changing climate on cropping are especially pronounced in Western Australia as the state has undergone a significant shift in rainfall patterns, in particular a southward movement of weather systems.



CSIRO researchers Chao Chen and Andrew Fletcher.

The Western Australian wheatbelt covers about 60,000 square kilometres and produces close to one quarter of the nation's crop, valued at $1.4 billion.

Shifting yields

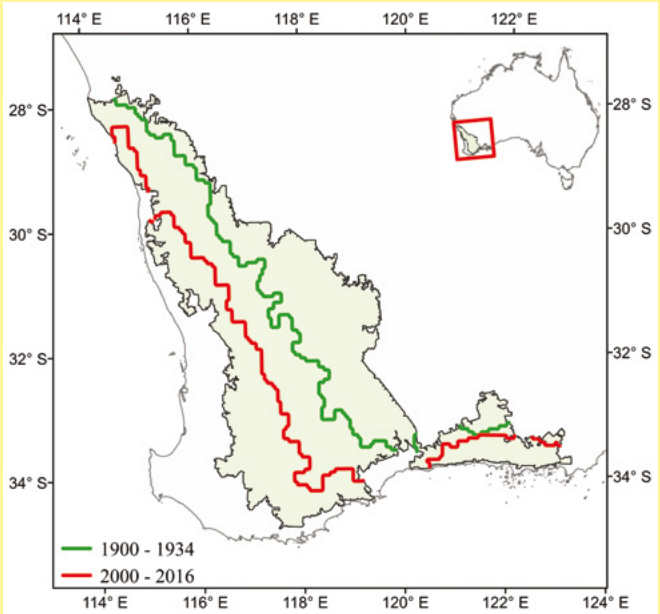
While the overall yield potential in Western Australia shifted on average 70 km to the southwest, this is being offset by 35 km due to increased CO_2, which improves plant growth. But overall the benefits of increased CO_2 are far outweighed by a reduction in rainfall– the major limiting factor to crop growth.

In the future, the gap between yield potential and actual yields will likely close due to climate change as potential yields decrease.

Similar shifts in yield potential, as seen in Western Australia, are likely to have occurred in other parts of Australia and in other countries. But to-date, the analysis that was done for this study has not been carried out elsewhere.

The research was supported by investment from the Grains Research and Development Corporation. ■

FIGURE 1: Yield potential in the Western Australian wheatbelt has shifted on average 70 km southwest from 1900 to 2016



Baiting snails – success is all about the timing

TIMING is everything when it comes to effective baiting of snails. And the optimal time to bait snails is in autumn before egg laying begins – a message to grain growers that has been reinforced through ongoing research.

To inform growers' baiting practices, the seasonal activity patterns of snails in different conditions across eight sites in South Australia and Western Australia continues to be investigated.

This research, led by the South Australian Research and Development Institute (SARDI), the research division of Primary Industries and Regions SA, has found that:

- For common white snails in SA and WA, reproduction generally occurs from April to mid-spring.
- The onset of reproduction can vary greatly from year to year and is largely dependent on rainfall. A wet start can lead to earlier snail reproduction.
- Snails 'shut down' their breeding activities between August to October depending on the finish to the season.
- Snail baits appear to kill snails more efficiently during times of the year coinciding with snail reproduction.

SARDI entomologist Helen Brodie says the aim of baiting is to control snail populations by knocking out mature snails before significant reproduction has occurred.

"Snails are most efficiently killed by baiting in early autumn. At this time, prior to and during reproduction, snails are active, hungry and the most vulnerable to the bait active ingredients."

Introduced round and conical snails cause significant economic losses to Australian growers and require an effective year-round management response, one element of which is baiting.

SARDI entomologist, Helen Brodie.

Helen says of the few molluscicide active ingredients available, metaldehyde is the most commonly used.

"Unfortunately, snail baits in general are not attractive to snails over distance," Helen says. "They will not seek the baits out, so the baits need to be placed at a time and sufficient density to ensure snails encounter them before the baits degrade and become less effective.

"Baits must be applied just before prolonged periods of snail activity to ensure pellet encounter. If growers are unsure whether snails are active, then it is best to bait a small area and check for dead snails after a few days."

It is important to gain an even spread of snail bait by calibrating spreaders for the selected bait product, and monitoring outputs.

Optimal baiting

Optimal baiting efficacy requires at least 30 pellets per square metre. In areas of higher snail densities, up to 60 pellets per m^2 may be required to ensure adequate rates of encounter. If this is above the registered rate of the product, repeat applications may be necessary, ensuring label directions are followed.

Helen says it is important for baits to be stored correctly and to be deployed at the right time to ensure maximum effectiveness.

"Environmental conditions will affect bait efficiency. We found that exposure of baits to high temperatures did reduce the active ingredient concentration over time, but UV exposure had no effect," she says.

"Iron chelate products are less effective if exposed to rainfall above 35 millimetres, but extended high rainfall will break down most bran-based pellets regardless of active ingredient.

"It is important to be aware of the temperature and rainfall forecast before spreading baits, and to store snail pellets in cool and dry conditions. Storing baits in a shed where the temperature regularly exceeds 40°C can cause bait degradation."

Potential bio-control of snails

Helen is also involved in GRDC-invested collaborative research, led by CSIRO in partnership with SARDI, looking at biological control of snails. This work has involved evaluation of a Moroccan parasitic fly strain, which scientists hope to deploy as a biological control tool targeting the introduced conical snail.

The fly species is a natural parasitoid (parasite that eventually kills its host) of the snail species in its native habitat across Europe and northwest Africa and was chosen for its genetic and climatic credentials.

More information on snail control and the latest research insights can be found in the GRDC Grains Research Update paper at *https://bit.ly/2yGAZoD* and in the GRDC Snail Bait Application Fact Sheet at *https://bit.ly/2xccXRQ* ■

Snail dying from eating bait. (PHOTO: SARDI)

Markets spooked by bad weather

By Peter McMeekin

THE world wheat market was at the whim of the weather in late May with futures markets bouncing sharply off an eight-month low (set just a week earlier) as concerns for the state of the European Union (EU) winter crop started to outweigh those of the Russian crop.

As the world emerges from the global coronavirus shutdown, northern hemisphere weather, especially in the EU, Russia and Ukraine, will most likely be the key wheat market drivers throughout June.

The buyers supposedly came back into the market on talks of decreased production in Russia, but most analysts appear to be holding their estimates firm in the 75–77 million tonnes (mt) range, well up on last year. The winter wheat areas received some rainfall in May and are holding production but by late May the spring wheat areas, particularly in Siberia, appeared to lack moisture and the 14-day forecast was not favourable.

The newswires tend to focus far too intently on Russian crop prospects these days, as they are the world's biggest exporter of wheat, and tend to set global export values.

Interestingly, with restrictions on Russian wheat exports for the last two months of the current marketing year, the EU has usurped their crown for the 2019–20 season, as their exports pass the 35 mt mark, with six weeks of the old crop year remaining.

Large swathes of western and central Europe have low soil moisture levels as the winter crop moves into its reproductive phase – the peak water use growth stage. Daytime temperatures have also been above average. Additionally, many spring crops were sown into inadequate moisture and germination has been poor.

Romania and Bulgaria would appear to have serious production losses in the offing as drought conditions persist (late May). Soil moisture is so poor in some areas that crops are reported to be stunted and showing signs of wilting and early leaf senescence. While not as acute, there are also production issues in Austria, Slovakia and the Czech Republic.

Yield estimates provided in late May by the European crop monitor, MARS, put the total EU wheat crop at around 139 mt. This is about 16 mt lower than the 155 mt produced in 2019–20.

Window for crop damage still wide open

The window for serious damage to the northern hemisphere crop is still wide open. All the major crop failures in Russia of recent times have been a result of the weather problems in June, July and August, so there is still oodles of time for production prospects to worsen – or improve.

In May's global supply and demand estimates by the USDA, total 2020–21 wheat production in the seven major exporters was 1 mt higher than last year at 378 mt. But a production decrease amongst the northern hemisphere exporters of 10 mt was more than offset by a 12 mt production increase by the southern hemisphere exporters – namely Australia and Argentina.

In other words, the global wheat balance sheet is relying heavily on the increase in southern hemisphere production. The challenge is the Australian and Argentinian winter crops are still being sown. They have the entire production cycle ahead of them, and the resultant output won't hit the export market for another six months.

The washup here is the EU, Russian and Ukraine winter crops need rain, and they need it quickly.

The big unknown is what impact has the coronavirus had on global wheat demand? If demand recovers quite quickly, then further supply issues will be bullish for new crop values. If there has been some severe erosion of global wheat demand then the market can absorb further northern hemisphere production issues with little upward pressure on price.

For more information call Grain Brokers Australia on 1300 946 544. ■

Adapting to a post-Covid-19 South East Asian grain market

AS recession looms in South East Asia, artisan cakes and pastries are off the menu, and instant noodles and biscuits are in – with Australian grain exports into the region forecast to shift accordingly.

Rabobank Singapore-based grains specialist Oscar Tjakra says while Covid-19 had flattened the consumption outlook for the region, demand was expected to shift from premium products to lower-end alternatives.

And with 40 per cent of Australian wheat exports sold into the South East Asian market, Oscar believed there would still be opportunity for Australian wheat, particularly for low to mid-grade varieties.

For barley, although South East Asia would not be able to replace China as a destination for the same quantity of Australian barley, it would provide an alternative export market, he says.

Low to mid-protein wheat

Oscar says demand in the region for cheaper-end products that require a slightly lower-grade of milling wheat, such as instant noodles and biscuits, would remain firm.

This increased demand for lower-end alternatives would, he says, counters the loss of demand for high-grade wheat – typically used in higher-end products such as cakes and pastries –

Oscar Tjakra.

and support stable demand across the whole wheat complex.

He said instant noodles remaining cheaper than rice in Indonesia – a large importer of Australian Premium White wheat – would also play into Australia's favour.

But Oscar is forecasting flat demand for milling wheat, with a best-case scenario of marginal growth – at 1.5 per cent in 2020, considerably lower than pre-Covid-19 forecasts.

Feed grain complex

With less disposable income among South East Asian consumers, Oscar says, animal protein consumption would also drop, driving down demand for grain in the feed complex.

"In the five major South East Asian countries – Indonesia, Vietnam, Philippines, Thailand and Malaysia – we forecast that the demand for grains and oilseeds for animal consumption to drop 5.5 per cent, year on year," he says.

African swine fever impacts, slowing economic growth and reduced food service all contributed to the significant decline.

A record planting of corn in the US, coupled with a slump in oil prices, would also increase the availability of global corn for exports, at a relatively low trading price – limiting the potential for feed wheat into Philippines and Vietnam, two countries Oscar says had become increasingly important markets for Australian feed wheat.

Alternative barley market

Following the recent announcement of 80 per cent tariffs on Australian barley into China, Rabobank senior grains analyst, Cheryl Kalisch Gordon said, South East Asia, while unable to replace the quantity China had secured in recent years, would provide an important alternative market.

"Thailand is one of the fastest-growing destinations for Australian feed barley, and, with recent drought in the region, there's been a much-reduced domestic production of rice, corn and cassava typically used to support feed rations," Cheryl says.

While this drought resulted in a need for imported grain, Oscar says Thailand's government regulations aimed at protecting local farmers would still restrict Australian product into the country.

"Thailand's feed millers are required to purchase domestic corn over imported feed wheat at a ratio of three to one," he says. "But even after importing the required feed wheat, there is still a gap, and Thailand fills this gap with Australian feed barley."

With Australia positioned as Thailand's sole source of feed barley, Oscar says it was still unclear whether the South East Asian country could be the next major market for Australian feed barley.

"I think this will all depend on the animal feed composition in Thailand. There is potential to increase Australian feed barley into the swine feed mix, but all of this will depend on feed barley price and a strong marketing effort by Australia."

Further information visit the podcast, *Will South East Asia Look to Australian Wheat and Barley in 2020/21*, available at *https://research.rabobank.com* ■

Freedom of crop choice restored

AFTER 16 long years, South Australian growers are now closer to having the freedom of choice to grow the same crops as their mainland interstate counterparts.

This follows the passage of the Genetically Modified Crops Management (Designated Area) Amendment Bill through State Parliament, which Grain Producers SA has welcomed.

The Bill will enable growers on mainland SA to access GM crop varieties while allowing a path for those councils which believe they derive a premium the ability to apply to the Minister for Primary Industries and Regional Development in the next six months to retain the moratorium for that council area.

GPSA CEO Caroline Rhodes said the passage of the Bill reflected GPSA's strong commitment to restoring grower choice in South Australia.

After 16 years, SA is transitioning out of the GM moratorium.

"This Bill establishes a level playing field for South Australian growers with their mainland interstate counterparts," she said.

"GPSA has been steadfast in its advocacy for freedom of choice and has worked tirelessly behind the scenes to reach this outcome and to support the political deliberations of both the Government and Opposition.

"While the amended Bill is not in absolute alignment with GPSA's preferred policy position, we believe this compromise model was the best opportunity to provide certainty for the industry in time for the 2021 season.

Transition out of GM moratorium

"This will hopefully be the start of an orderly transition towards removing restrictions on GM crops in SA, after 16 long years under the current moratorium."

Caroline thanked both the Government and Opposition for their commitment to supporting freedom of choice for South Australian growers.

"Ever since the independent review by Emeritus Professor Kym Anderson found there was no trade or marketing benefit to SA from the GM moratorium, the Government has had a clear mandate to remove it," she said. "We are backing the state's grain industry to manage the transition out of the moratorium in a sensible manner and look forward to growers finally being able to make their own choices about which crops they want to grow." ■

Nigeria has given a new GM cowpea variety the go ahead

By Jose Maria Barrero and TJ Higgins, CSIRO

IN late 2019 the world's first genetically modified (GM) cowpea was registered and approved for release to smallholder farmers in Nigeria. The new variety carries a microbial insecticidal gene making it resistant to a major pest that affects this crop.

The decision is significant because this will be the second GM crop commercialised in the country following Bt Cotton, and the first one that is a food crop.

The release of a GM crop in Africa is particularly noteworthy as many countries on the continent are still wary of biotechnology.

It is important for another reason too: Cowpea, also known as black eyed pea, is a staple crop in the country and is an important source of protein for over 200 million people. Nigeria is also the world's largest producer of cowpea. But it still has to import around 500,000 tonnes to meet internal demand. This is because the potential loss in yield due to insects is over 90 per cent.

By controlling one of the major pests – the cowpea pod-borer – the country could become self-sufficient. It could also potentially help reduce rural poverty and hunger. Nigeria has a massive poverty problem – more than 91 million people are estimated to live without enough food to eat.

Australian involvement

The new variety, named Sampea 20-T, carries a microbial insecticidal gene from a bacterium and represents a biotechnology product that has been nearly 20 years in the making. It is fully resistant to the damaging pod-borer insect.

It was developed by an international team, led by the African Agricultural Technology Foundation in collaboration with CSIRO in Australia and the Donald Danforth Plant Science Center in the US.

The gene used to develop this variety was provided by Bayer on a humanitarian basis, so that smallholder farmers could access it royalty-free.

There's been a very slow uptake of GM crops across the African continent. The messages from an anti-GMO organisations sent from Europe has been an obstacle in many African countries. But thanks to science outreach efforts and community information sessions, the concerns about GM crops are left behind.

Over the past 20 years some of the political resistance and public fear have been overcome, and several African countries including South Africa, Burkina Faso, Egypt and Sudan have introduced GM crops. Many more countries now have passed laws to allow the cultivation of GM crops.

The team that has developed Sampea 20-T was formed in response to requests from African cowpea breeders for a solution to the cowpea pod-borer.

Developing the new variety using traditional breeding was not possible due to the lack of any resistant breeding stock. This means that there were no sources of natural resistance to insects in cowpea anywhere in the world. The only solution possible was to create a GM insect-resistant cowpea using biotechnology.

The partners, supported by the US Agency for International Development and also by the Rockefeller Foundation and the CSIRO, worked to develop a cowpea variety that would provide in-built protection against the pest, allowing a cheap, safe and practical solution to the problem.

The only option farmers have at the moment is to apply chemical insecticides to control the pest. These are expensive and can be dangerous if they aren't familiar with how to use them safely, or don't have the necessary protective clothing.

Future prospects

The new cowpea variety is expected to be taken up by a number of countries in West Africa including Ghana, Burkina Faso and Niger.

And work on new varieties continues. A second generation of improved cowpea carrying more than one type of Bt gene is under development. This, together with an appropriate insect resistance management plan for the right use of this product, will help guarantee long-lasting protection against the pod-borer and future-proofing the benefits of this biotech product. ■

Cowpea, also known as black eyed pea, is a staple crop in Nigeria.

THE SCIENCE BEHIND THE PROJECT

The new variety carries a gene from *Bacillus thuringiensis* (Bt). This is a soil bacterium that can produce a natural insecticide which has been used by humans to control insect pests for over 80 years. It was discovered at the beginning of the 20th century by a Japanese biologist Shigetane Ishiwatari who found that it was killing silkworms.

It was first used as an insecticide on flour moths in the 1930s, but it was in the 1980s that the use of Bt increased worldwide due to insects becoming resistant to many chemical insecticides.

The toxin produced by the bacterium is a crystalline inclusion (called crystal) in the Bt spores. There are many types of Bt crystals, and they have specific toxicity against an insect species, but are innocuous to other insects or animals.

Bt crystals have been part of commercial insecticide formulations for decades and are the principal active ingredient of organic insecticides. With the adoption of gene technology, GM plants were first produced in 1995 by introducing in them the genes that encode the toxic crystal from Bt.

Subsidised agriculture around the world: The impact on Australia

By the Australian Farm Institute and GrainGrowers

AT A GLANCE

- Australian government farm support is among the lowest of OECD countries;
- Support has been reducing over the past two decades;
- Since 2009 no more than 0.19 per cent of Australia's annual GDP has been provided as support to the agriculture sector – a proportion less than all international competitors;
- It is critical that government policy settings are right for Australian farmers' ongoing international competitiveness; and,
- The Australian grains industry can provide the green shoots of economic recovery but an ambitious trade policy agenda and a reduction in unnecessary red tape is needed.

Australian barley exports to China have been effectively suspended based on conjecture and not evidence.

AUSTRALIAN agriculture is a highly globalised industry, with 71 per cent of all production being exported. This global exposure means that economic, trade and political factors in other countries can have significant impacts on the operations and profitability of Australian farmers and the industry. These impacts are exacerbated as Australian farmers receive very little government support relative to other countries.

Recent events, including Covid–19 disruptions to supply chains, have amplified the effects of uncertainty in the global market on Australian agriculture. For example, the allegation that Australia has been dumping barley into China and providing countervailing subsidies to farmers damages a trade relationship which was worth $1.5 billion in 2018, despite a lack of evidence for the claim.

Accurate representation of Australian agriculture's position on the global playing field is vital to ensure just trade negotiations and underpin ongoing market access. This article outlines the very low levels of support Australian farmers receive relative to other countries, using data from the Organisation for Economic Co-operation and Development (OECD), and highlights some implications for the agricultural sector and trade positions.

How does Australia compare?

The OECD (2020) collects data to provide regular updates and estimates on the levels of farm support provided in countries around the world, defining agricultural support as:

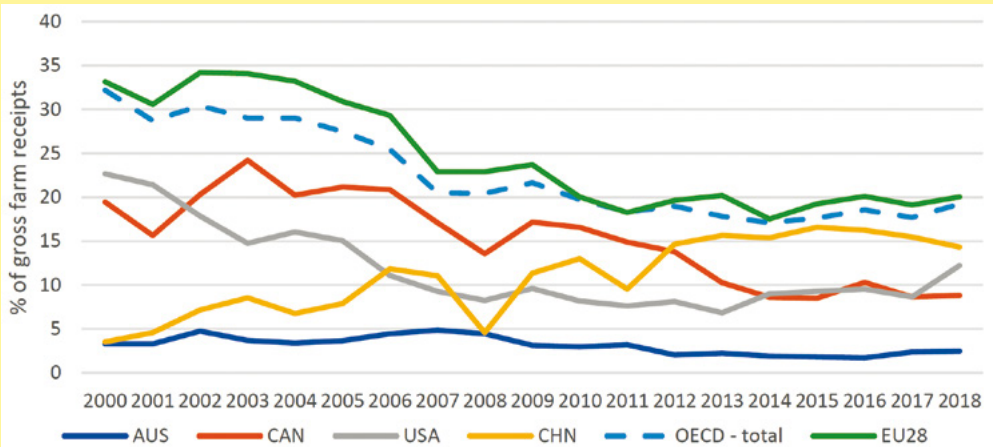
"the annual monetary value of gross transfers to agriculture from consumers and taxpayers arising from government policies that support agriculture, regardless of their objectives and economic impacts."

Figure 1 shows the Producer Support Estimate[1] (PSE) of Australia, Canada, the US, China and the EU from 2000–18 as a percentage of gross farm receipts. Over this time period Australian farmers have received an average of three per cent of their gross farm income as support, while Canada has averaged 15 per cent, US 12 per cent, China 11 per cent and European farmers have received 25 per cent as support. \

Australia's PSE is the second-lowest (just behind New Zealand) of countries monitored by the OECD, and has been steadily reducing over the past two decades. Indeed, across the Australian economy the inexorable reduction in government protection for some key parts of industry has resulted in the effective rate of assistance for the agriculture and manufacturing sectors reaching an historic low (Productivity Commission, 2020).

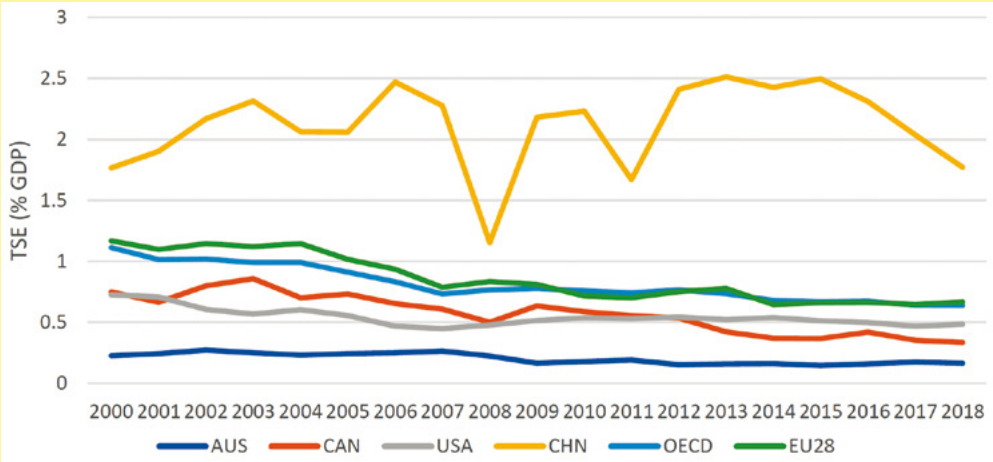
The Total Support Estimate (TSE[2]) provided to agriculture sectors in the same countries (which includes transfers other than direct payments to farmers) shown in Figure 2, again demonstrates the extremely low level of comparative support provided to Australian agriculture. In fact, since 2009 no more than 0.19 per cent of Australia's annual GDP has been provided as support to the agriculture sector. Australia has the lowest TSE of any country monitored by the OECD.

FIGURE 1: Producer support estimate (PSE) by Country, 2000–18



Source: Based on OECD, 2020.

FIGURE 2: Total support estimate (TSE) by country, 2000–18



Source: OECD, 2020.

What support do Australian farmers receive?

The small percentage of farm gate revenue provided to Australian farmers included in the PSE is entirely in the form of what the OECD defines as 'input use' support, which includes drought-assistance measures such as concessional interest rates on loans for upgrading on-farm water infrastructure and equipment. The remaining direct support Australian producers receive is aimed at managing risk through mechanisms such as farm management deposits and income tax averaging arrangements.

Industry support, such as expenditure on agricultural research, development and extension (RD&E) and infrastructure, as well as smaller levels of inspection, control, marketing and promotion, is measured by the OECD through the general services support estimates (GSSE) indicator. A comparison between different countries of the proportion of total support (TSE) that is provided as GSSE again highlights the very low levels of direct support to farmers in Australia.

In 2016–18, approximately 55 per cent of Australia's agricultural TSE was made up of GSSE. In the same period, GSSE in countries with more intensive direct farmer support policies accounted for a much smaller approximate percentage of total TSE (e.g. China 15 per cent; US and EU both 10 per cent), indicating a greater proportion of direct (non-RD&E related) support such as minimum prices on specific commodities.

Implications of global farm support policies

Anderson and Valenzuela (2020) have calculated that Australian annual farm exports were reduced by 29 per cent ($10.4 billion) and net incomes of Australian farms lowered by 15 per cent ($6.1 billion)[3] in 2014 due to the support policies for farmers in other countries. The primary impact on Australian agriculture calculated in this report (75 per cent) was attributed to protectionist policies of China, the EU, Korea and Japan, which (along with Indonesia and the US) have some of the highest levels of support for their farmers.

Market price support (MPS) mechanisms through import barriers (tariffs) or minimum price support for specific commodities, are a common form of government intervention utilised globally. Artificial price signals delivered through MPS lead to production decisions which are not reflective of true supply and demand issues, creating market distortions which undermine and threaten Australia's trade competitiveness.

GrainGrowers CEO David McKeon said Australian farmers are clearly being negatively affected by the support policies received by their counterparts across the globe.

"Australian grain farmers operate in highly competitive international markets; they face the full exposure of market volatility and localised climate variability," David said.

"With Australian farmers receiving less government support than all their international competitors, it is critical that we get policy settings right. Our government policy settings on trade, RD&E, infrastructure and regulation are fundamental to our ongoing international competitiveness."

Australian Farm Institute Executive Director Richard Heath said in times of uncertainty it is more important than ever to ensure that policy decisions are based on evidence, not conjecture.

"Australian agriculture is facing a range of current market access challenges, whether they be for pulses into India or barley into China, and we need to base our discussions on the facts and also clearly understand the ramifications on Australian, and indeed farmers across the globe, from such policy decisions," he said.

"China's imposition of barley tariffs has effectively ended Australian barley sales based on an unsupported allegation of subsidisation is a clear example of the need to present data clearly and dispassionately.

"Industry credibility comes from transparency and authenticity," Richard said. "This credibility is essential to maintain mutually beneficial trade relationships, and for this parties must engage in evidence-based discourse."

1. Producer support estimate (PSE) is measured at the farm gate level and includes support mechanisms and policies such as cost of revenue foregone, market price support and budgetary payments.
2. Total support estimate (TSE) is the sum of all estimates including PSE and general services support estimates (GSSE) which includes policies where agriculture is the main beneficiary but do not include direct payments.
3. Estimated annual cost to Australia's national economic welfare, net farm income and agricultural exports of global agricultural assistance (all trade measures and budgetary transfers), by policy instrument, 2014 (Anderson & Valenzuela, 2020). ■

Managing N fertiliser to profitably close yield gaps

By James Hunt (La Trobe University) and James Murray (BCG)

At a glance…

- In low rainfall environments with heavy soils, applied N surplus to crop requirements is available for use by subsequent crops.
- The most profitable treatments to-date use *Yield Prophet* yield potentials at 75 per cent or 50 per cent probability, and N banks targeting 100 or 125 kg per hectare N.
- Over application of N has been more profitable than under application.

Recent research by Zvi Hochman, Heidi Horan and others shows that Australian wheat yields are only half what they could be for the rainfall received. Nitrogen (N) deficiency is the single biggest factor contributing to this yield gap. This is also likely to be true for other non-legume crops (barley, canola and oats) which reduces farm profitability and global food security. Alleviating N deficiency would increase national wheat yields by 40 per cent.

On farms with no legume pastures, most of the crop N supply must come from fertiliser. Grain legumes do not provide enough N to support yield of subsequent crops at the intensity at which they are currently grown. N fertiliser is a costly input and use of it increases cost of production and value-at-risk for growers. Growers fear that over-fertilisation will result in 'haying off', which reduces both yield and quality. There is also concern that overapplied fertiliser not used by crops is lost to the environment by leaching, volatilisation and denitrification.

Consequently, efforts are made to match N fertiliser inputs to seasonal yield potential. This is difficult in southern Australia due to the lack of accurate seasonal forecasts for rainfall.

The difficulty in matching N supply to crop demand and a tendency for growers to be conservative in their N inputs is responsible for a large proportion of the yield gap that can be explained by N deficiency. Chronic N deficiency has also caused soil organic matter to decline and driven a rise in the proportion of low protein grain produced in Australia, which has eroded our standing as a producer of quality wheat in export markets.

Paddock details	
Location	Curyo
Crop year rainfall (Nov–Oct)	2018 – 200 mm 2019 – 368 mm
GSR (Apr–Oct)	2018 – 138 mm 2019 – 149 mm
Soil type	Sandy loam top-soil with clay content and calcium carbonate increasing with depth
Paddock history	2017 – Lentil
Trial details	
Crop types	2018 – Scepter wheat 2019 – Hyola 350 TT canola
Treatments	Refer to Table 1
Seeding equipment	Knife points, press wheels, 30 cm row spacing
Sowing dates	14 May 2018 29 April 2019
Replicates	Four
Harvest dates	15 November 2018 15 November 2019
Trial inputs	
Fertiliser	Refer to Table 2 and Table 3 for nitrogen fertiliser applications in 2018 and 2019. 2018 – Urea at 35 kg/ha at sowing (host farmer management). 2019 – Granulock Supreme Z at 60 kg/ha at sowing.
Weeds, pests and disease were controlled according to best management practice.	

What we set out to do

To evaluate different nitrogen management systems designed to profitably close the yield gap due to N deficiency.

Chris Cook, BCG Technical Officer, entering data at the Curyo trial site.

How we did it

A long-term experiment using a complete randomised block design was established in 2018 to evaluate the performance of different N management systems. Two different systems were tested:

3 Cumming Avenue
PO Box 85, BIRCHIP Vic 3483
Ph: 03 5492 2787
E: info@bcg.org.au – Web: www.bcg.org.au

Chief Executive Officer: Fiona Best

Overview: Birchip Cropping Group Inc. (BCG) is a not-for-profit agricultural research and extension organisation led by farmers from the Wimmera and Mallee regions of Victoria. Our aim is to improve the prosperity of farmers and agricultural communities through farmer-driven innovation, research and extension.

Recognised both nationally and internationally by the industry as a credible, independent and innovative organisation, BCG's research and communication activities provide evidence, support and tools for improving farm management practices and profitability.

BCG has been integral in the adoption of new agronomic technologies and farming practices; and continues to help farmers make decisions, develop risk management strategies, increase profits and operate sustainable farming operations.

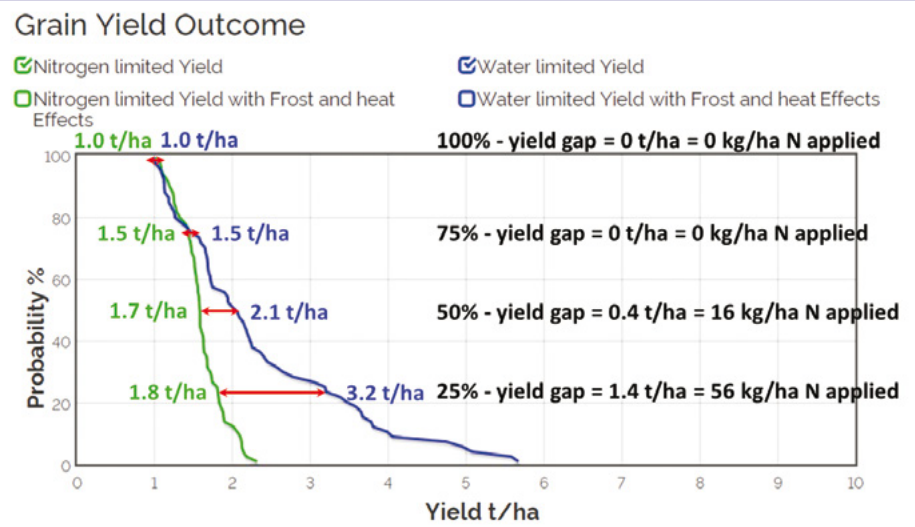
BCG members enjoy access to premium information, including technical bulletins, BCG Season Research Results and free entry to flagship events.

- Matching N fertiliser to seasonal yield potential (*Yield Prophet*); and,
- Maintaining a base level of fertility using N fertiliser (N banks).

Within each of these systems there were different treatments targeting different yield potentials (Table 1). In the *Yield Prophet* treatment, water limited potential yield was determined at different levels of probability and the amount of N required to achieve these yields applied, assuming a requirement of 40 kg per hectare N per tonne per hectare wheat yield and 80 kg per hectare N per tonne per hectare canola yield (Figure 1).

For the N bank treatments there were different target levels of N fertility (N banks). N fertiliser rate in these treatments was calculated as the N bank value minus soil mineral N (kg/ha) measured prior to sowing.

Figure 1: An example from 2018 of how *Yield Prophet* is used to determine water limited potential yield given probabilities of different season outcomes, and how this is used to calculate a yield gap and the N fertiliser rate required to close the yield gap



All gross margins were calculated using values from the 2019 SAGIT Gross Margin Guide (SAGIT 2019).

Table 1: Nitrogen management systems and treatments used in the experiments

System	Treatment	Description
Nil	Nil	No nitrogen applied other than in starter fertiliser
Nitrogen banks (kg/ha N)	50	Soil mineral N + fertiliser = 50 kg/ha N
	75	Soil mineral N + fertiliser = 75 kg/ha N
	100	Soil mineral N + fertiliser = 100 kg/ha N
	125	Soil mineral N + fertiliser = 125 kg/ha N
	150	Soil mineral N + fertiliser = 150 kg/ha N
Yield Prophet probabilities	100%	Yield with lowest yielding season finish on record
	75%	Yield with lower yielding quartile season finish (decile 2.5)
	50%	Yield with median season finish (decile 5)
	25%	Yield with higher yielding quartile season finish (decile 7.5)

Table 2: Amount of N fertiliser top-dressed, wheat grain yield, grain protein and gross margin for all treatments in 2018

Strategy	Treatment	Top-dressed N (kg/ha)	Grain yield (t/ha)	Grain protein (%)	Gross margin ($/ha)
Nil	Nil	0	1.5	10.0	131
Nitrogen banks (kg/ha N)	50	0	1.6	9.6	131
	75	28	1.7	9.7	98
	100	53	1.8	9.8	69
	125	78	1.5	10.4	40
	150	103	1.5	10.2	10
Yield Prophet probabilities	100%	0	1.5	9.7	131
	75%	0	1.6	10.4	131
	50%	16	1.5	10.1	112
	25%	56	1.7	10.3	65
	MEAN	**33**	**1.6**	**10.0**	
	Sig. diff.		**0.694**	**0.310**	
	LSD (P=0.05)		**NS**	**NS**	

Results and interpretation

2018

In 2018 there was 47 kg per hectare mineral N (nitrate + ammonium) in the top one metre of soil when measured before sowing. The trial was implemented in an area of farmer managed crop which had received 16 kg per hectare N applied in-furrow as urea at seeding. Scepter was dry sown on May 14 and did not emerge until after enough rain fell to wet the seed bed in the last week of May. Urea was top-dressed on August 28 (crop at GS32) according to the different treatment criteria in Table 1 and only 8 mm of rain fell in the 45 days after application.

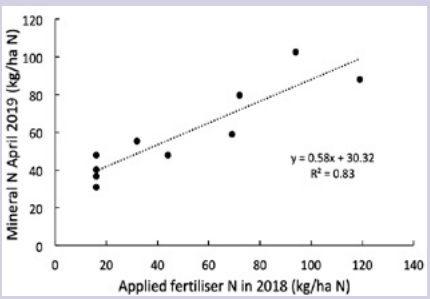
The dry conditions following application meant there was no crop uptake of top-dressed fertiliser N, with no significant differences observed in crop biomass or N uptake at flowering or grain yield and protein (Table 2). Mean yield was 1.6 tonnes per hectare and mean grain protein content was 10 per cent indicating that yield was N limited despite the dry seasonal conditions.

There were no treatment effects on screenings or test weight, and gross margins for each treatment were calculated assuming 1.6 tonnes per hectare yield and APW quality. Differences in gross margin are due to different rates of N fertiliser application (Table 2).

2019

In 2019 there was an additional 0.6 kg per hectare of mineral N measured prior to sowing for every kg per hectare N top-dressed in 2018 (Figure 2 and Table 3). This indicates the majority of applied

Figure 2: The relationship between fertiliser N applied in 2018 and soil mineral N (nitrate + ammonium) measured prior to sowing in 2019



Linear regression is of the form y=0.6x + 30 (P<0.001, R=0.80) meaning that for every 1 kg/ha of N fertiliser applied in 2018, 0.6 kg/ha was available as mineral N prior to sowing in 2019.

BCG working in the real world. The main BCG trial site at Curyo where the Yield Gap trial is located, being planted in mid May 2020. It's also full steam ahead on the neighbouring commercial paddock.

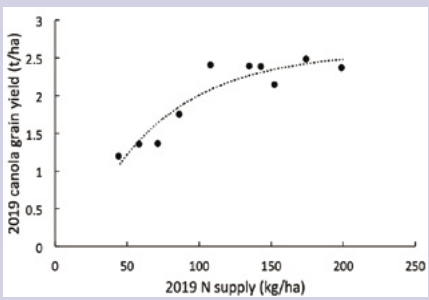
N not used by the crop in 2018 was carried over for use by 2019 crop in mineral form. Of the remainder of the N applied in 2018 and not measured in soil N, some would have been immobilised into organic form, and some possibly lost due to volatilisation and/or denitrification. Despite 200 mm of rain falling in a single event from December 11 to 15, 2018, there appears to have been little leaching, as demonstrated by no significant difference in mineral N at 0.7–1.0 m between treatments.

Low levels of loss and carryover of unused N in low rainfall environments with heavy soils, corroborate recently published studies from southern NSW.

The canola crop was top-dressed on June 28 (six leaf) at different rates (Table 3) according to the treatment criteria in Table 1. Yield was strongly related to total N supply (soil mineral N + fertiliser N) and maximised at about 100 kg per hectare N (Figure 3). Oil concentration was negatively affected by N supply (Table 3). Increase in yield during the linear phase of the response validated current rules of thumb with 83 kg per hectare N being required per tonne per hectare of canola grain yield up to 90 per cent of water limited potential yield.

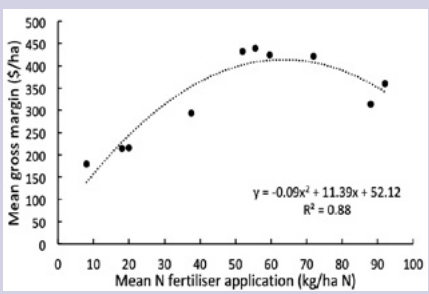
Within treatments that were not N limited, there was no relationship between the proportion of total N fertiliser applied in 2019. This indicates that N fertiliser applied in 2018 and not used in that year was used as efficiently by the 2019 crop as N applied in 2019.

Figure 3: The relationship between N supply (soil mineral N + applied N fertiliser) and canola grain yield in 2019



Fitted exponential function is of the form y = 2.6 – 3.2(1.0x) (P<0.001, R=0.85).

Figure 4: The relationship between two year mean annual fertiliser N application and mean annual gross margin of the different treatments



Two-year summary

There was a parabolic relationship between mean application rates for the different treatments and gross margin (Figure 4). The most profitable treatments to date are Yield Prophet 75 per cent and 50 per cent probability and N bank 100 and 125 kg per hectare treatments. These treatments averaged 50–70 kg per hectare N top-dressed per year. Treatments that under applied N are less profitable than treatments that over apply. This is partly due to poor marginal nitrogen use efficiency (NUE, kg/ha grain produced per kg/ha N applied relative to the nil control) of low rates of N application.

The reasons for this low NUE are unclear but could be due to microbial immobilisation or low levels of N contributing to vegetative, but not reproductive, growth.

Commercial practice guide

Growers should use soil nitrogen tests in combination with *Yield Prophet* or an N bank target to ensure they have applied enough N to achieve water limited potential yield and optimise profitability. Long-term profitability is likely to be increased by being less conservative with N fertiliser applications, particularly for growers consistently achieving cereal grain proteins of less than 10.5 per cent (i.e. ASW).

Growers in low rainfall regions with heavy textured soils can be confident that applied N not used in year of application will remain in the soil for use in subsequent seasons and is not a lost cost.

Further research is required to confirm the robustness of these results over different sites and seasons to ensure there are no negative consequences (e.g. haying off or environmental losses) due to maintaining high levels of soil mineral N as per the N bank treatments.

This research was funded by La Trobe University through the Securing Food, Water and the Environment Research Focus Area.

Table 3: Soil mineral N, amount of N fertiliser top-dressed, canola grain yield, grain oil and gross margin for all treatments in 2019

Strategy	Treatment	Soil mineral N (kg/ha)	Top-dressed N (kg/ha)	Grain yield (t/ha)	Grain oil (%)	Gross margin ($/ha)
Nil	Nil	37	0	1.2	43.7	226
Nitrogen banks (kg/ha N)	50	31	20	1.4	44.3	298
	75	48	31	1.8	43.4	488
	100	59	42	2.4	42.3	810
	125	103	25	2.4	41.7	810
	150	88	57	2.2	40.2	618
Yield Prophet probabilities	100%	40	24	1.4	44.4	300
	75%	48	88	2.4	41.9	734
	50%	55	112	2.5	40.4	730
	25%	80	112	2.4	39.7	655
	Sig. diff.	**<0.001**		**<0.001**	**<0.001**	
	LSD (P=0.05)	**17**		**0.5**	**0.7**	

Weed competitive abilities in Australian barley genotypes

By Bhagirath S. Chauhan[1] and Gulshan Mahajan[1]

AT A GLANCE…

- Weed-suppressive ability (WSA) and weed-tolerance ability (WTA) of Australian barley genotypes can be used as a tool in integrated weed management (IWM) programs.
- High tiller production and plant height are competitive characteristics in barley.
- Genotype Commander had strong WSA and WTA; genotype Westminster had strong WSA.
- These superior genotypes suit both low and high production systems, as well as organic farming systems.

BARLEY is a vital winter cereal crop for the Australian brewing and pork industries. The presence of weeds in barley cropping systems impacts not only yield, but also the renowned quality of Australia's spring-type barley for malting purposes. Despite an increased reliance on herbicides, the rising costs, environmental concerns and evolution of herbicide-resistant weeds make the need for IWM strategies vital to counteracting the $3.3 billion annual yield loss caused by weeds.

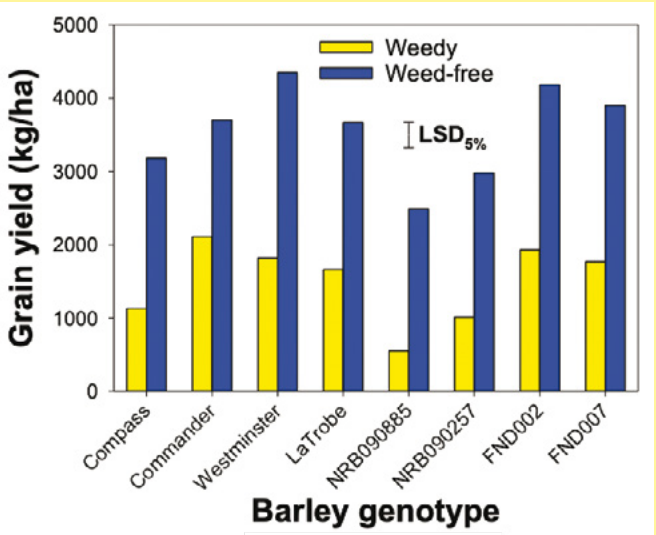
Breeding techniques have helped to improve the yield and malting quality of barley, but the weed-competitive ability of these genotypes remains unknown. The WSA, in particular, indicates the crop ability to reduce the weed seed bank, presenting an IWM strategy against common weeds in barley. These include black/wild oats, annual ryegrass, paradoxa grass and some broad-leaf weeds.

This article describes research into the ranking of WSA and WTA in barley genotypes. It also presents how this competitiveness affects crop yield under weed infestation.

What we did

The experiment included eight barley genotypes grown under weedy and weed-free conditions with three replications (Table 1).

FIGURE 1: Interaction effect of barley genotype and weed treatments on barley grain yield



The barley was planted in May of 2017 (first run) and 2018 (second run) at a density of 125 seeds per square metre and row spacing of 35 cm. The crop was irrigated to maintain sufficient soil moisture and harvested in October/November of that year.

Commercial oat (weed, hereafter) was used to create weedy conditions. For this purpose, weed seeds were sown at a density of 40 plants per m^2 in the weedy plots. All plots were treated with metsulfuron-methyl to control broad-leaf weeds.

Weed biomass was determined by cutting all aboveground plant material from two quadrats of 0.25 m^2. Biomass was dried in an oven for three days at 70°C before being weighed. Barley grain yield was obtained using a plot harvester and adjusted at 12 per cent moisture.

Trial site at University of Qld, Gatton, where eight barley genotypes were grown under weedy and weed-free conditions.

WTA was calculated as 100 x (BYw/BYwf), where BYw is the barley yield in the weedy plot and BYwf is the barley yield in the weed-free plots. WSA was calculated as 100 per cent dockage (percentage of weed seeds in each sample).

The trial was conducted in two years but the year-difference was non-significant; therefore, data of the two years were pooled and presented.

What we found

The barley genotype significantly affected weed (oat) biomass and weed (oat) seed production. Weed biomass was greatly reduced in Commander, Westminster, FND002 and FND007, with the populations in Commander and Westminster amounting to only half the amount found in LaTrobe (Table 1).

Similarly, weed seed production in Commander was 37 per cent less than LaTrobe, and 73 per cent less in Westminster.

TABLE 1: Effect of barley genotypes on weed biomass and weed seed yield

Genotype (plant type)	Weed (oat)	
	Biomass (g/m²)	Seed yield (kg/ha)
Compass (droopy)	476	1290
Commander (droopy)	279	1100
Westminster (droopy)	238	470
LaTrobe (erect)	525	1750
NRB090885 (semi-erect)	548	1150
NRB090257 (droopy)	509	1390
FND002 (droopy)	250	950
FND007 (droopy)	240	1030
LSD 5%	100	540

Barley grain yield was also affected by the interaction of genotypes and weed treatments (Figure 1). Commander produced the highest yield in weedy conditions, while weed-free Westminster and FND002 were significantly superior to other genotypes. Grain yield varied from 2500 to 4350 kg per hectare in the weed-free plots and 550 to 2100 kg per hectare in the weedy plots.

Commander and LaTrobe showed the highest WTA – ability to tolerate weeds (Table 2). Commander and Westminster were the top-performing genotypes for weed suppression (WSA). The WSA was found to directly correlate with the height and panicle number in barley in competition with weeds (data not given). Crop yield under weed-free conditions was also correlated with WSA, and both WSA and WTA were correlated with yield in weedy conditions.

TABLE 2: Ranking of barley genotypes for weed-tolerance ability (WTA) and weed-suppressive ability (WSA)

Genotype (plant type)	Rank	
	WTA	WSA
Compass (droopy)	6	5
Commander (droopy)	1	2
Westminster (droopy)	5	1
LaTrobe (erect)	2	6
NRB090885 (semi-erect)	8	8
NRB090257 (droopy)	7	7
FND002 (droopy)	4	3
FND007 (droopy)	3	4

Commander

LaTrobe

A groundcover view of Commander and LaTrobe barley genotypes. These two genotypes had the highest weed tolerance ability.

To sum up

The results of this study show the variation between WTA and WSA in different barley genotypes. Importantly, a strong WSA did not always imply a similar WTA. Westminster showed a superior WSA without a similar WTA and LaTrobe was the opposite. But both WTA and WSA show the potential to prevent yield loss in situations of weed infestation.

Traits of increased plant height and tiller number also prevented yield loss without weed infestation.

The superior WTA and WSA in Commander shows the potential for a high-yielding and weed-competitive genotype desirable to growers to be developed in future. We recommend that further studies involving a greater variety of weeds (e.g., turnip weed, annual ryegrass, wild radish, etc.) be undertaken to further explore this IWM opportunity in Australian barley production.

The competitive ability of genotypes may vary with region, growing environment and management conditions. Therefore, it is important for growers to make observations and learn from their own experience with different genotypes. Future studies, involving metabolite differences in genotypes regarding physiological and biosynthetic differences that may impact crop competitive traits against common weeds, are needed.

1. Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton 4343, Australia. ■

A newly discovered bacterium could yield a new bioinsecticide

By Jan Suszkiw, Agricultural Research Service, USDA

THE tidal marshes along the lower Potomac and James Rivers in Maryland and Virginia support a rich array of aquatic and terrestrial wildlife – from blue crab and bass, to mud turtles, white-tailed deer and waterfowl among other inhabitants.

Now, from this same marshland habitat comes a newly discovered species of bacteria that could help keep destructive crop pests at bay.

A team of Agricultural Research Service (ARS) scientists collected the bacterium from marsh water and sediment samples. They named it *Chromobacterium phragmitis* and determined that it was a new species using genetic sequencing techniques in studies at the ARS Invasive Insect Biocontrol and Behavior Laboratory (IIBBL) and the agency's Electron and Confocal Microscopy Unit – both located in Beltsville, Maryland.

The researchers have since begun testing the bacterium's lethality to the cabbage looper, seedcorn maggot, red flour beetle and other pests.

Their efforts are part of the IIBBL's overarching mission to find cost-effective and sustainable means of insect pest control that can ease the reliance on synthetic insecticides – or serve as an alternative to them, such as for use by organic growers.

A newly discovered marsh-loving bacterium, *Chromobacterium phragmitis* could yield new bioinsecticide ingredients. (PHOTO: Joseph Mowery)

The researchers' tests of *C. phragmitis*, reported in the January 2020 issue of the Journal of Entomological Science, expand on the findings of retired ARS microbiologist Phyllis Martin. She identified the very first insecticidal Chromobacterium species in 2003 from decomposed hemlock leaves collected in the Catoctin Mountain area of north-central Maryland.

That species, which Phyllis named *C. subtsugae*, was subsequently licensed by a commercial firm and sold under the trade name Grandevo.

"Chromobacterium species are not insect pathogens, they just happen to make things that kill insects. This is actually very nice, because you don't need to spray living bacteria," commented Michael Blackburn, an ARS entomologist with the IIBBL.

Michael and his colleagues Robert Farrar, Jr. (also retired), Dawn Gundersen-Rindal, Daniel Kuhar, Ashaki Mitchell, Joseph Mowery and Michael Sparks are keen to learn whether their marshland discovery, *C. phragmitis*, possesses the same "recipe" for pest-control success that Phyllis's species does – namely, a cocktail of compounds that repel, slow the growth of, or kill susceptible insect pests.

Wider application

Those compounds, which include Chromamide A, proved toxic to varying degrees to Colorado potato beetles, corn rootworms, diamondback moths, whiteflies and other agricultural pests, some of which have become resistant to commonly used insecticides.

Of four strains of *C. phragmitis* that the researchers tested in insect-feeding trials, one labelled IIBBL 113-1 proved most lethal to immature cabbage loopers, adult red flour beetle, seedcorn maggots and diamondback moths.

Cabbage loopers, leaf-eating caterpillar pests of both garden-variety and commercially grown crops, were especially vulnerable and began dying off three days after ingesting artificial diet pellets containing the rod-shaped bacterium. By six days, 100 per cent had died.

According to Michael, upcoming research will include determining what makes *C. phragmitis* toxic to these pests and identifying non-target insects that could be affected – information important to ascertaining the bacterium's commercial prospects as a bioinsecticide.

C. phragmitis is one of several Chromobacterium species that the team has discovered, and in particular by Robert. His "prospecting" for this group of purple-colored bacteria ranged from Maine to Florida.

The team named *C. phragmitis* after the wetland grass species that dominated the marshland sites where the microbe was found. It is further described in the *International Journal of Systematic and Evolutionary Microbiology*.

"Chromobacterium is known to inhabit wet habitats, so we sampled as many types of marshes and bogs as we could find," explained Michael. "Thus far we don't know if the insecticidal factors from other species are the same or different as the commercialised one. But IIBBL 113-1 was the most toxic strain of *C. phragmitis* we isolated." ■

Microalgae food is good news for honey bees and farmers

By Kim Kaplan, Agricultural Research Service – USDA

A MICROSCOPIC algae (microalgae) could provide a complete and sustainably sourced supplemental diet to boost the robustness of managed honey bees, according to research just published by Agricultural Research Service scientists in the journal *Apidologie*.

Poor nutrition in honey bees is often an underlying factor in colony losses because malnutrition amplifies the detrimental effects of parasites, pathogens and pesticides. Habitat loss, decreases in flowering plant diversity and large tracts of crop monoculture (cultivation of a single crop over a large area) all can potentially contribute to lessening natural pollen sources, which provide bees with essential nutrition.

Now, research by ARS entomologists Vincent Ricigliano and Michael Simone-Finstrom has shown that the microalgae *Arthrospira platensis* (commonly called spirulina) has a nutritional profile that closely resembles pollen. Spirulina is a part of a family of blue-green algae, which are single-celled organisms that exist individually or in chains or groups.

Vincent and Michael found that spirulina is rich in essential amino acids and lipids required by bees, with levels matching those found in tested pollen samples.

The two scientists are both with the ARS Honey Bee Breeding, Genetics, and Physiology Research Laboratory in Baton Rouge, Louisiana.

A blue-green microalgae could provide a strong, sustainably produced artificial diet for honey bees. (PHOTO: Vincent Ricigliano)

"Our work is a pioneering first look into the nutritional and functional properties of a single microalga and how well it corresponds to what is needed in a complete pollen substitute for the honey bee," explained Vincent.

In addition to being rich in essential amino acids necessary for protein synthesis, immune function and colony growth in honey bees, spirulina also contains prebiotics that support the growth of healthy gut bacteria.

Commercial beekeepers have become increasingly reliant on artificial pollen substitute diets to nourish colonies during periods of pollen scarcity as well as to bolster colony size before they fulfill pollination service contracts.

Currently available commercial diets for bees usually incorporate a variety of ingredients such as soy, yeast, wheat, lentils and milk proteins in an effort to supply balanced nutrition. These artificial diets are sometimes deficient in essential macronutrients (proteins, lipids, prebiotic fibres), micronutrients (vitamins, minerals), or antioxidants.

"So the need to scientifically improve the efficacy of pollen substitutes can be considered vital to modern beekeeping and we need to think about how we can do it in a sustainable way," Vincent said.

Microalgae can be sustainably grown on a large scale with a minimal amount of water and few chemical inputs. It can even be grown in places where soybeans and other crops cannot be grown.

"All it takes are shallow ponds, nutrient salts and sunlight to produce highly nutritious microalgae," said Vincent.

Now, the researchers are testing the microalgae diet in a field setting to make sure the diet is attractive to bees and supports colony growth. The excellent nutrition profile of spirulina suggests that there are likely other microalgae that could serve honey bees well, Michael pointed out.

"We have also begun development of new microalgae strains to address other aspects of bee health, including targeted nutrition strategies," Vincent added.

The Agricultural Research Service is the US Department of Agriculture's chief scientific in-house research agency. ■

HOVERFLIES GIVING BEES A HELPING HAND

Move over bees – hoverflies could be our new favourite buzzy buddy. According to researchers at the University of WA, hoverflies could become vital to future food security and ecosystem health as our other pollinator pals struggle to survive.

Like bees, wasps and butterflies, hoverflies are effective pollinators. Research shows that hoverflies 'visit' more than 70 per cent of global food crops – worth US$300 billion per year – as well as over 70 per cent of the world's wildflowers.

In addition, hoverflies provide ecosystem functions not seen in bees, including crop protection from pests, recycling of organic matter and long-distance pollen transfer.

Migratory species are hugely abundant and unlike many insect pollinators, do not yet appear to be in serious decline.

Hoverflies are extremely effective pollinators visiting more than 70 per cent of of global food crops every year. **(PHOTO: Pekka Malinen)**

More information:
The Royal Society review: *Pollination by hoverflies in the anthropocene*
Proceedings of the Royal Society B: Biological Sciences

OUR AUSSIE BEES MEAN THE WORLD TO US

Minister for Agriculture, Drought and Emergency Management, David Littleproud, says a number of bee pests and diseases are a potential risk to our honey bee industry, environment and to Australia's native bee populations.

In recognition of the crucial role that bees play in supporting food production, the government granted $1.5 million to AgriFutures in 2019 for research to ensure bee health and promote the crucial role bees play in supporting our food production.

"Australia is home to over 1500 species of native bees, the vast majority of which are actually solitary species," David said.

"Pests and diseases of bees not only have the potential to devastate bee colonies, but may also impact on the health of native plants should our bees be unable to pollinate them.

"Alongside our hardworking European honey bees, Australia's native bees also play an important role in pollinating commercial crops such as mango, blueberry, eggplant, tomato, almonds and macadamia, as well as native plants.

"The Australian Chief Environmental Biosecurity Officer is working with Plant Health Australia to investigate the biosecurity risks to our native bees," David adds.

"The project will look at ways to control pathways that may allow exotic bees or pests to enter Australia. The result will be improved responsiveness for biosecurity risks to Australian native bee species for the protection of native ecosystems and biodiversity.

"The project will deliver other benefits including identifying threats for better decision-making about resource allocation and preparation and strategies to protect Australian native bee populations. It will also complement existing efforts and recent improvements through the Agricultural Competitiveness White Paper to manage biosecurity risks to the European honey bee.

"The recent summer of bushfires and drought have had a significant impact on our floral reserves and on pollinators. As part of the recovery, beekeepers are currently eligible for grants of up to $75,000 to pay for clean-up and business reinstatement activities."

Weather models revolutionising forecasting accuracy

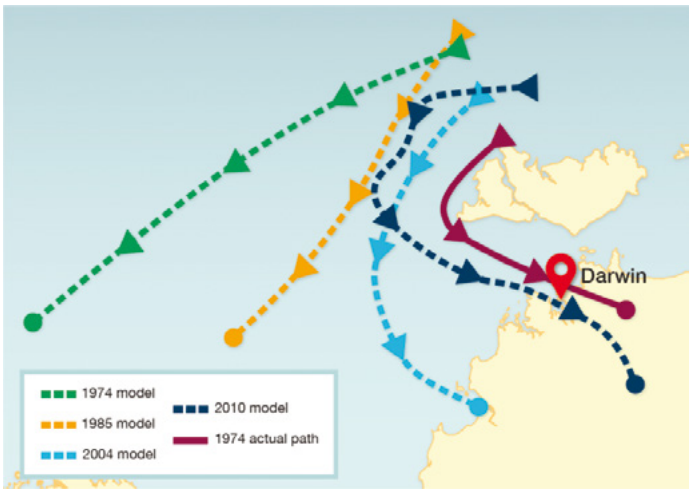
By the Australian Bureau of Meteorology

IT'S no exaggeration to say computer weather models have revolutionised weather forecasting in the modern era – and they're getting smarter all the time! So, what are they, how do they work and what can they tell us about our dynamic weather and climate?

What is a computer weather model?

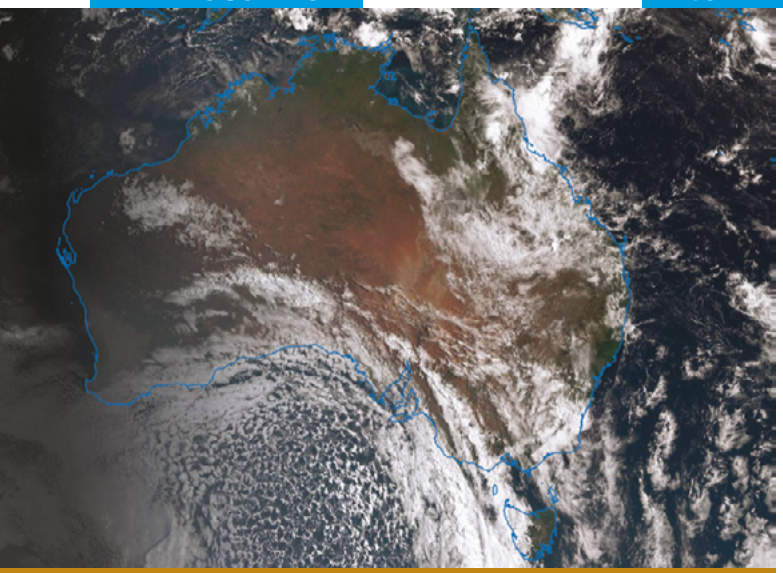
Computer weather models are the main tool we use to forecast weather – as well as a key tool to research the processes that drive weather and climate. The models, also known as numerical weather prediction (or NWP) models, essentially create a virtual planet Earth, simulating the atmosphere, ocean, land surface and sea ice, and use mathematical equations to predict future weather.

Weather models have revolutionised the science of weather prediction. Improvements in models, and a vast increase in the observation data that feeds them, are a big part of why our seven-day forecasts today are about as accurate as a three-day forecast in the early 2000s. The map opposite shows how steadily improving weather models between 1974 and 2010 would have forecast the path of severe tropical cyclone Tracy, coming closer and closer to the path it actually took.



How do weather models work?

Weather models carve up the atmosphere into a large number of grid boxes, vertically and horizontally. We take what we know about the weather now – readings from all levels of the



Australia, seen from the Japan Meteorological Agency's Himawari satellite. In the southern hemisphere, satellites are a key source of the observations that feed into weather models.

atmosphere and under the ocean known as 'observations' – and feed it in.

As the models step forward in time, the temperature, humidity and wind in each grid box are updated by calculating heat, moisture and momentum (wind) transfer into and out of the grid box. This takes into account the way the atmosphere interacts with the ocean and land surfaces, such as sunlight heating the ocean and snow cooling the land.

Many processes in the atmosphere (such as thunderstorms and clouds) happen at scales much smaller than the size of the grid boxes used in most models – although this is changing as models improve. Depending on the model, we approximate these elements in each grid box using additional sets of equations.

Taking all the mathematical equations that explain the physics of the atmosphere and calculating them at hundreds of millions of points around the Earth is an enormous job. That's why the models need vast computing power to complete their calculations in a reasonable amount of time, meaning they must use some of the most powerful supercomputers in the world.

Our supercomputer can handle more than 1600 trillion calculations per second!

We don't just run the equations once either – under some circumstances we run them multiple times, each with slightly different starting conditions. This is called ensemble forecasting. It tells us whether small changes in the atmosphere or ocean are likely to cause a shift on the forecast.

To calculate climate outlooks (a forecast covering the next three months) we run them 165 times. If most of the runs come out with the same result, for example a wetter or drier-than-average season, then the odds are higher for that outcome.

If the model runs show a range of outcomes – some suggest wetter and some drier – then there's no strong signal one way or the other, which means there's a roughly equal chance of wetter or drier conditions.

What can they tell us?

The models can help us predict weather and ocean behaviour from time scales of hours to days to weeks to seasons. They can also help us with prediction and trajectory of severe events, such as tropical cyclones, rainfall and flooding, ocean waves, storm surges and tsunamis.

We also use models in research, to increase our understanding of the physical processes that drive weather and climate and the role played by interactions between the atmosphere and elements such as land, oceans and ice. An example is modelling how pyrocumulonimbus clouds (caused by bushfires) develop and behave.

This should lead to better ability to forecast these dangerous conditions in the future – and the insights we gain are also used to improve the models.

Models can also help us understand the changes we are seeing in our climate over time. Estimating the relative contributions of natural variability and climate change to past extreme events such as record-breaking heat is one way of investigating this. It's done by retro-modelling the weather systems that caused the heat, but with less CO_2 in the environment than was historically the case and seeing how that changes the outcome.

What does the future hold?

All the time scientists are working to make weather models more accurate. Basically, this boils down to being able to input better data about current conditions such as temperature, humidity and air pressure at the start of the process, and being able to run the models at a 'finer resolution'.

This means that each of the grid boxes that the atmosphere is divided into is smaller, which allows greater detail in the modelling. It's like the difference between looking at a road map at the regional level, showing highways and main roads, and zooming into your town or suburb, with every street showing.

The resolution in forecast models is ever-improving. Our current global weather forecasting model has 25 km grid squares, but our forthcoming model has double the resolution, with 12 km grid squares.

Our model for short-range forecasting over more limited areas (for example covering eastern NSW) has grid squares 1.5 km wide.

As the models improve, the time-steps between model calculations decrease, so we also get a faster result.

Of course, all that adds up to more and more equations, so being able to run the improved models depends upon enough computing power being available to crunch the numbers.

When the models are calculated at a more detailed level, forecasts overall become more accurate and our ability to forecast things that happen at a very local level should also improve. For instance, fog that may affect airports, or thunderstorms. These are examples of weather phenomena that are influenced by the local details at the surface, such as the shape of the terrain, as well as the larger-scale weather patterns.

Working with multiple models

Australia has its own weather and climate model, developed by the Bureau and CSIRO. It's called the Australian Community Climate and Earth System Simulator ('ACCESS' for short). But there are several other models around the world that we also look at when making weather and climate forecasts.

These include models from meteorological agencies in Japan, the US, the UK, France and Canada – and one that is a collaboration between more than 30 European nations (called ECMWF).

When the output from a number of local and international sources are blended, weather forecasts are more accurate.

Models around the world have common elements but also differ, particularly in the additional equations they use to approximate the smaller-scale weather processes.

It's useful to watch models from other regions as well as our own because if more models are showing a particular outcome (such as a developing low-pressure system that may form into a tropical cyclone) we can have increased confidence in the likelihood that it will happen.

And when we blend the output of the various models, the results are more accurate than any single model. This is also relevant for predicting climate drivers such as the El Niño–Southern Oscillation and the Indian Ocean Dipole, where we provide an average of international models as part of our own outlook. ■

Quality formulation

CLETHODIM is an important herbicide in the control of annual ryegrass in canola in southern Australian cropping systems. But are all clethodim formulations equal?

Select Xtra (clethodim 360 g/L) is a new generation of clethodim with a worldwide patented formulation.

While best known as the high load version of one of Australia's most widely recognised grass herbicides, it is Select Xtra's unique formulation that sets it apart from other clethodim products in the market.

Ian Cass, UPL Australia marketing manager, said that the patented formulation delivers a better spraying quality, an improved stabilisation over time and a high level of performance against grasses.

"Select Xtra sets a new formulation standard for clethodim," he said, "and to understand what sets it apart you need to look at the components of the herbicide."

"Clethodim is a specific graminacide and hardly miscible with water, so to improve the quality of the emulsion, there's a need to add surfactants," Ian said. "Our formulation contains proportionally more surfactants that improve spraying quality, which in turn gives an improved clethodim performance."

Clethodim molecules have a weak bond and are sensitive to surfactant exposure, which can damage the clethodim molecule over time. To counter these effects and retain the surfactant interest, UPL formulation specialists have added epoxidised vegetal oil which contains strong reactive epoxide bonds. This means that surfactants will preferably attack these bonds instead of the clethodim molecules.

"The vegetal oil therefore acts as a protection barrier for clethodim, stabilising it over time for better longevity," Ian said.

Proven performer

"Select Xtra has proven itself in the market as a performer," he said. "It's reliability stems from these unique components that improve the spraying quality and maintain product integrity over time."

He added that aside from the formulation quality, Select Xtra provides a cost benefit from using a high load product and is also user friendly.

"It's a convenient herbicide for farmers to use, being rainfast within an hour of application and with a nil plant back period," he said. "Farmers also benefit from handling less product on farm and during application."

Select Xtra is compatible with a number of grass herbicides, and with LeMat insecticide, for a wider spectrum of control. The herbicide also has a broad window of application and safety on a large range of broadleaf crops.

"Growers looking for maximum performance from a clethodim application this winter can look to Select Xtra to deliver against grass weeds," Ian said.

"Select Xtra sets a new standard in clethodim formulations, showing that when it comes to selecting clethodim, not all formulations are equal." ■

Make the most of a good start

AFTER a number of very tough seasons back-to-back, things are looking positive for a good winter crop yield. Autumn rain events have put some good moisture in the ground and now is the time for growers to take advantage and maximise their yields with good fertiliser programs. Since Yara started in Australia in 1994, the company's focus has been on providing leading crop nutrition products, specialising in dry applied, water soluble, bulk liquid and foliar fertilisers.

"To determine exactly which fertilisers a grower needs, we recommend they take regular soil and leaf analysis to assist in determining the best fertiliser program," says Jason Brady, Yara Australia Sales Agronomist, WA. "Yara has some very stringent quality controls and testing in place to make sure that all fertiliser products are of the highest quality and easy to use.

"By far the most required micronutrient across Australia is zinc. Adequate zinc is essential for root development at crop emergence due to its role in growth hormone synthesis. And YaraVita Zintrac is one of the best products to address this.

"Each crop needs specific nutrients, and the YaraVita range of micronutrient fertilisers also includes products such as YaraVita Mantrac Pro (manganese deficiency), YaraVita Coptrac (copper) and YaraVita Gramitrel – a multi-nutrient fertiliser.

The availability of these micronutrients throughout the whole season is important to maximise yield potential. Even though the plant's requirement for these micronutrients is small, efficient plant growth and function cannot occur without adequate levels.

The compatibility of YaraVita products – and their extended nutrient release patterns – allows simple, effective fertiliser programs to be implemented within standard field passes.

"One or two targeted samples taken after the end of tillering can quickly identify how the crop is progressing and what additional nutrients are required," Jason says. "Our colleagues in New Zealand used this approach in the crop nutrition program for Eric Watson's world record wheat crop (16.71 tonnes per hectare) achieved two years ago. "They used YaraVita Gramitrel as the foundation of the micronutrient program, with YaraVita Zintrac and YaraVita Mantrac as required."

YaraVita products have excellent compatibility with a range of crop protection products but always check tank-mix partner compatibility by visiting the Yara website or downloading the Yara Tankmix app. See www.yara.com.au ■

Resurgence of deep ripping

WINTER traditionally is not a time that we see much ripping going on across the Australian wheatbelt. But there are strong signs that winter 2020 may be a little different as demand remains high for a variety of styles of deep ripper for a number of different purposes. Many farmers have found the traditional 'ripping window' to be too narrow to get the workload done.

The resurgence of deep ripping as an important farming tool continues to gather pace. Whilst the drought squeezed cashflows, it also created a large-scale rethink on the long-term benefits of deep ripping, particularly in the eastern and southern cropping areas of the country. Farmers in traditionally wet areas went in search of buried moisture while others in drier areas sought to capture as much moisture as possible from the extremely limited rainfall.

Whilst this certainly was not a complete solution to the dire drought situation, it definitely helped many operations, and this has led to a renewed level of interest in the practice of ripping.

Of course, none of this was particularly newsworthy in Western Australia, where the farmers in the wheatbelt have long had access to strong data promoting the benefits of deep ripping!

Customisation

TTQ's focus on customisation has seen the company produce some interesting machines so far in 2020:

- A pair of 15 metre wide rippers for Central NSW that were the widest machines we'd ever made (and therefore, probably the widest rippers ever made);
- Some 12 metre wide Raptor rippers that needed some very innovative folding systems due to the size and weight of the shank systems; and,
- An 'armoured' deep ripper for some development country in Queensland.

TTQ conducted a number of field days across South Australia and Victoria before Covid-19 stopped play and as soon as we can get back out there, we will be rolling out demos in Queensland, New South Wales and Western Australia as well as revisiting the two southern states.

Recent orders have seen TTQ develop their first ever parabolic tyne and an interchangeable hitch system that will allow the rippers to be more easily attached to a number of machines.

The recent drought conditions encouraged a re-think about deep-ripping benefits.

At the back of the machines, TTQ has developed a range of tow bars to suit a variety of carts, predominantly for fertiliser. These are coming with pre-fitted hydraulic attachments to make them truly 'plug and play'.

In the near future TTQ will be working with one of the prominent research universities to help them expand their trials of deep placement improvements using a hybrid machine that will certainly make heads turn when it goes past!

To increase service and sales support across Australia, TTQ is expanding their agent network. In the meantime, if you don't know who your nearest agent is, just call us directly and we will introduce you.

TTQ operates under the philosophy that 'the farmer knows best' and so long as the engineering drawings pass the test, they will continue to custom-make machines to suit specific requirements rather than offer a generic range of fixed machines. The innovative nature of TTQ designs not only makes this possible but also allows you to change your mind down the track and reconfigure the machine completely!

That is certainly 'having your cake and eating it' – about time many of you may say! We agree.

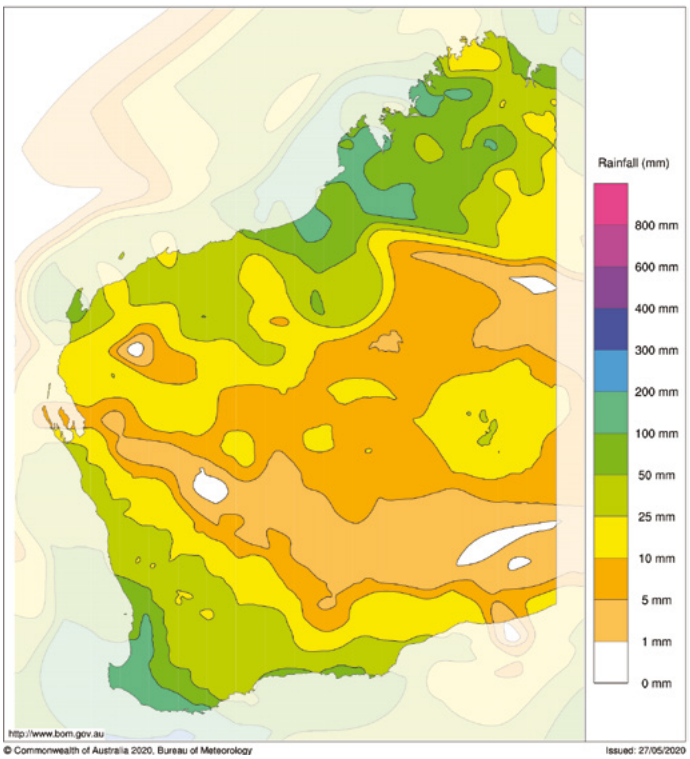
Phone TTQ on 07 4634 0800 or see *www.ttq.net.au* ■

TTQ custom makes deep rippers for specific requirements.

District Reports...

Western region

Western Australia rainfall totals (mm) for April 1 to May 27, 2020
Australian Bureau of Meteorology



After a generally dry April and May, ex-cyclone Mangga delivered some useful rain to WA cropping regions in late May. But this dramatic change to the weather, also brought with it damaging winds.

WESTERN AUSTRALIA SUMMARY

With rainfall in the first week of May across parts of the WA grainbelt, the much anticipated early start to the 2020 cropping season was 'hit and miss'. Some growers in a line from north of Merredin down to Hyden and Jerramungup received nice early May falls, with others missing out completely.

The areas receiving good falls of rain have good subsoil moisture and growers were able to put a reasonable area of cereals in. The areas closer to the west coast generally received just enough rain (6 to 12 mm) to get dry-sown lupins, canola and oats out of the ground.

The north western Geraldton zone missed out on the early May rain and large sections of the grainbelt away from the eastern regions and further south also received very little rainfall. The central Midlands region from Coorow down to the Kwinana zone to Tammin also mostly missed out on rain.

The majority of the central and eastern areas of the Esperance port zone also missed out on the early May rain, but unfortunately, did not miss out on strong winds.

By the end of the first week in May, around 40 to 50 per cent of the state-wide crop had been sown although this varied from region to region.

The medium term forecast for the season is more positive than this time last year, with the chance of rain towards the end of May. If this eventuates, Western Australia could still be on track for at least an average production year.

Grain Industry Association of WA, May 9, 2020

Editor's note: In late May, damaging winds, showers and thunderstorms occurred in WA as ex-tropical cyclone Mangga interacted with a strong cold front. The rainfall recorded across most cropping regions was generally enough to initiate germination of drysown crops and to complete sowing programs.

But in some areas, re-sowing of crops damaged by the strong winds, was required.

The June outlook by the Bureau of Meteorology is also a very positive one with a 75 per cent chance of rainfall totals between 10 and 50 mm across WA's cropping regions.

NORTHERN DISTRICT

How much can the world change in two months? Coronavirus lockdowns are lifting in our area. We were all pretty worried about the implications for farm businesses particularly if coronavirus got on-farm and caused a shut-down for a couple of weeks. Many started self and business isolation in mid March. Thankfully the virus has been kept out of our region.

When the pubs etc were shut before Easter it meant that the seeding crew had nothing else to do except go seeding! This means that most seeding programs are about a week ahead of schedule.

By the end of the week (May 22) most farms will have everything dry-sown that can be. It will then be a waiting game for rain to complete the program.

Most farms are 60 to 90 per cent complete with those in the western areas generally having a bit more than that still to be planted.

Rainfall wise it is very dry at the moment but there were some showers and storms on May 4 and 5. Most of the region only had 2 to 5 mm in that event but there were a few strips under storms with 15 to 30 mm. There are reports of a couple of crops that have emerged and died. These areas had 5 to 7 mm which germinated the crop with no moisture underneath. Those areas are being re-sown.

Everywhere is dry again now and looking for a good rain to get all crops up and away.

Generally, the farming landscape is pretty well positioned – but wet would be better than dry! The sown paddocks have gone into lighter stubble levels and seeding equipment has done a brilliant job.

As usual, we just need a good rain to get the season underway. Hopefully, next week's rain delivers a bit more than what is being forecast.

Peter Norris
Agronomy For Profit and Synergy Consulting, Geraldton
May 18, 2020

SOUTH COAST

Seasonal conditions in the WA South Coast cropping region have remained relatively dry over the past two months with only small and infrequent rainfall events.

Despite this, seeding has been progressing very well with most growers looking to finish in the last week of May with only field peas and some chickpeas to be sown as we head into June.

District Reports...

May–June 2020

Laura Sacilotto gives the thumbs-up to deep ripping. Laura is working on the property of MKM Farming in the Scaddan district about 50 km north of Esperance. (PHOTO: Quenten Knight)

'Smudging' underway at the property of MKM Farming, Scaddan. Smudging the spread clay ensures an even application while breaking up any large lumps. (PHOTO: Quenten Knight)

Early April sown Jurien lupins at the property of Keith and Emma Green who farm near Neridup, around 35 km northeast of Esperance. (PHOTO: Quenten Knight)

Craig Nield installing a weather station with Adcon telemetry at Scaddan. (PHOTO: Quenten Knight)

The early sown crops have germinated and established quite well and have tapped into some stored subsoil moisture. Those crops that were sown in mid May are a little more patchy and will require a decent rain to achieve a full germination.

Water supply is still a major problem for livestock and spraying. Many farm dams and tanks are either dry or running very low. Water is being carted in from large distances and at considerable cost.

At this stage, the emerged crops have very few agronomic problems – rainfall being the only missing ingredient.

Some growers had made the decision to drop barley from the rotation on the back of well-founded fears of barley import tariffs being imposed by China. In general, this area is being replaced by wheat.

Quenten Knight
Agronomist – Agronomy Focus, Esperance
May 18, 2020

Southern region

SOUTHEAST AUSTRALIA SUMMARY

During the week ending May 27, low-pressure systems and troughs resulted in useful rainfall in southeast Australia. Rainfall totals of between 10 and 25 mm were recorded across parts of eastern New South Wales and isolated parts of central Victoria and South Australia.

This has added to a generally very good start to the 2020 winter crop in southeast Australia thanks to the well-timed and widespread opening rains on Anzac Day.

District Reports...

May–June 2020

The Bureau of Meteorology is also saying there is a 75 per cent chance of June rainfall totals between 10 and 50 mm across the cropping regions of New South Wales, Victoria and South Australia.

ABARES Weekly Climate, Water and Agricultural Update May 28, 2020

VICTORIAN MALLEE

A fantastic early break has meant that Mallee growers have ripped in and vigorously started their sowing programs around Anzac Day. Reports from around the region have indicated between 60 to 80 per cent completion by mid-May. But the rains presented a few challenges with some growers experiencing difficulties when sowing into heavy stubbles.

Early rain and warmer weather have prompted excellent crop growth, particularly in early sown vetch and canola. This great crop establishment has boosted grower optimism across the region.

The good moisture profiles are causing some growers to rethink their crop choices and are re-evaluating paddocks earmarked for hay due to the expected decrease in feed demand.

Mice have been flagged early as a potential issue and growers are reporting higher numbers particularly in bean stubbles, paddocks that haven't been grazed and/or in those where there was significant grain loss from wind the previous season.

Growers are also busy inspecting for insects, planning for early nitrogen topdressing and rolling lentils while keeping an eye on pre-emergent herbicide performance.

Boom sprays are busy in the Mallee with work to be done ahead of the sowing rigs. Sprays are also underway to ensure that the early and now emerging canola and vetch crops are effectively treated with insecticide.

Mixed farmers are now well into the lambing season and are keeping a close eye on the nutrition available to their ewes. There have been some reports of stock losses due to exposure to the intense rains through April. Livestock are also being sent off to market which is allowing growers to sow into the grazed barley stubbles.

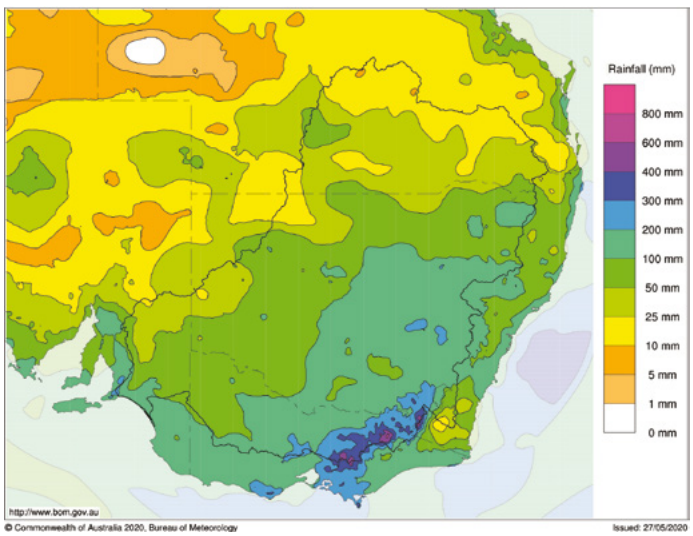
Wimmera-Mallee agricultural research organisation – BCG – has completed sowing around 70 per cent of their 2020 trial program. Around 13 per cent of the trial program had been completed prior to the Anzac Day downpour. Early sown trials have emerged and have already started to provide useful information to growers.

Tom Draffen
Birchip Cropping Group
May 19, 2020

The BCG 2020 trial program for canola has established well and is already providing useful information to growers. (PHOTO: BCG)

The excellent opening rains allowed sowing across the Mallee to get underway in ideal time. Pictured is an emerging crop in the Curyo district, about 30 km northwest of Birchip. (PHOTO: BCG)

Murray–Darling Basin rainfall totals (mm) for April 1 to May 27, 2020
Australian Bureau of Meteorology



In many Murray-Darling Basin cropping areas, rainfall totals of between 10 and 25 mm were recorded in late May which has added to the generally very good start to the 2020 winter crop growing season.

Northern region

QUEENSLAND SUMMARY

Following low rainfall during April and most of May in southern and central Queensland cropping regions, patchy rainfall in late May helped the establishment of early-planted crops and provided some much needed upper layer soil moisture. In many areas the upper soil layer had begun to dry out to an extent that crop roots were unable to access stored lower-layer soil moisture to support their growth.

These recent falls will go part way to address this issue but widespread above average rainfall in June and July will be required to replenish soil moisture profiles, improve crop establishment and development, and encourage additional winter crop plantings.

In very positive news, the latest Bureau of Meteorology climate outlook is a 75 per cent chance of rainfall totals between 25 and 100 mm between June and August across Queensland's cropping regions.

ABARES Weekly Climate, Water and Agricultural Update May 28, 2020

DARLING DOWNS

Regional summary

March and April have brought very little rain to the Downs, with few growers having more than 35 mm across a few showers. This has meant the summer crops planted in late January and February have mostly grown on the stored moisture from the initial rain, which wet soil down to about 60 cm in most cases.

Summer 2020

The main crops grown on this very late plant were sorghum and mungbeans, and harvest is just starting for both. Most of the mungbeans have been desiccated, and dryland yields are 1 to 1.5 tonnes per hectare whilst irrigated crops are yielding between 2 to 3 tonnes per hectare, and early quality is good, although the frost on the southern Downs may have caused some quality issues.

Much of the sorghum is still ripening and approaching

Seasonal rainfall across the grain regions – 25 year averages and year to date

Brought to you in association with JOHN DEERE

	25yr Annual Average (mm)	2020 rainfall to date (mm)	Summer 25yr Annual Average (mm)	Summer 2019–20	Autumn 25yr Annual Average (mm)	Autumn 2020 to date	Winter 25yr Annual Average (mm)	Winter 2019	Spring 25yr Annual Average (mm)	Spring 2019
Emerald Qld	560	348	256	287	106	61	67	44	125	6
Toowoomba Qld	678	333	271	304	143	53	87	25	179	124
Roma Qld	567	424	245	385	118	49	74	18	131	35
Goondiwindi Qld	609	200	242	212	124	23	98	27	145	36
Narrabri NSW	617	421	213	272	121	155	122	15	161	60
Gunnedah NSW	622	367	206	220	110	149	125	28	182	38
Dubbo NSW	583	398	183	120	125	280	127	24	180	32
West Wyalong NSW	433	346	114	112	79	239	121	48	120	41
Wagga Wagga NSW	524	231	130	39	110	200	146	78	141	91
Swan Hill Vic	307	141	68	44	65	103	87	72	88	37
Bendigo Vic	491	303	96	74	107	233	159	139	129	81
Horsham Vic	365	171	73	67	72	108	121	133	98	58
Lake Bolac Vic	507	234	105	102	107	139	155	170	141	113
Murray Bridge SA	356	138	64	38	81	104	120	109	93	50
Kadina SA	328	67	59	41	79	39	108	76	82	59
Cummins SA	394	129	50	43	92	95	176	148	76	68
Esperance WA	620	33	91	36	137	1	253	248	138	97
Wagin WA	392	88	50	49	89	40	168	211	85	49
Northam WA	407	70	51	44	84	27	192	200	80	38
Mingenew WA	347	104	32	87	84	16	174	232	57	26
Moora WA	385	64	46	46	79	19	191	199	69	36
Mullewa WA	310	99	48	66	89	37	130	146	43	12

Last rainfall reading May 25, 2020.

District Reports...

desiccation in the latter half of May, but there has been some frost damage south of Toowoomba which is shutting the crops down early. Of the early crops harvested west of Dalby, dryland yields are around one to four tonnes per hectare depending on short or long fallow. A few irrigated crops ripened early and yielded between seven to 10 tonnes per hectare, dependent on stored water and the amount of irrigation available.

The early May frost has also caused some damage to corn crops. The small area of cotton was all irrigated, and so far yields of 10–12 bales per hectare have been picked, again very much dependent on the amount of irrigation water available.

Winter 2020 outlook

The only planting able to be done so far has been deep sowing with moisture seeking equipment, mainly with chickpeas. But the outlook is promising.

The winter cropping area will be large this season, as there is a lot of country that has been fallow for some time. There is a strong interest in wheat and barley, although the barley area may reduce a little if the price drops due to the export market.

The chickpea area will be only about 30 per cent of the large areas grown in 2017, and will be slightly less than the traditional area. This is due to there being a large 'blank canvas' across many paddocks, and a need for cereal stubble for sustainability.

The early sown chickpeas and fababeans have been emerging well from as deep as 15 cm. Growers are hoping for a planting rain by early June, and that the forecasted improved outlook into the spring comes to fruition.

Hugh Reardon-Smith
Senior Sales Agronomist – Nutrien Ag Solutions Pittsworth
May 15, 2020

Harvesting of summer crops was a very rare sight around southern Qld in 2020. An even rarer sight is this drone's eye view of a dusk gathering of header, chaser bin and truck. The image was taken/piloted by nine-year old William Charles at his family's farm, Windella, near Cambooya on the Eastern Darling Downs. His father Jason is unloading irrigated grain sorghum from the header while his grandfather, Ray, empties the chaser bin. The MR Taurus crop went on to yield around 7.5 tonnes per hectare. (PHOTO: William Charles)

ANSWER TO IAN'S MYSTERY TRACTOR QUIZ

Answer to Ian's Mystery Tractor. The tractor is a Jelbart – the 82nd produced. Note the horizontal single cylinder engine. Owned by Tony Pailthorpe. Pictured at a rally at Kukerin, WA. (Photo IMJ)

ADVERTISERS' DIRECTORY

IN IT TOGETHER. IN IT FOR GOOD.

In who we are and what we do, we are driving a more responsible food system, one that sustains and enriches our lives and our planet.

Our Enriching Lives Together Sustainability Strategy advances sustainability for farmers, for the land, in our communities and in our operations. Our goals span across the globe and across our entire business. They help farmers flourish and increase the resilience of our global food system.

They activate the passion and expertise of our people, products, and partnerships to enrich our lives and our planet for generations to come.

Visit us at **sustainability.corteva.com**

CORTEVA™ agriscience

GREENMOUNT TRAVEL

WATCH THIS (wide open) SPACE!

Covid-19 has knocked *Greenmount Travel* out of the travel game this year but we will be back, bigger and better than ever in 2021 with the same great destinations postponed from 2020.

For more detailed information and updates visit

www.greenmounttravel.com.au

Contact details:
Lloyd (0428 724 615) or
David (0437 000 234)
Email: travel@greenmountpress.com.au
Or visit: *www.greenmounttravel.com.au*
for updates

GREENMOUNT TRAVEL
Licence No. TAG 1608
ABN 57085 828011
IATA 96-804831
Ph: 07 4659 3555
www.greenmounttravel.com.au
E: travel@greenmountpress.com.au
Fax: 07 4638 4520
2 Kirk St, Toowoomba Q 4350

The beating heart of harvesting.

It's here! The all-new CLAAS LEXION 8000 has arrived.

CLAAS LEXION 8000/7000 combine harvester

CLAAS LEXION is already recognised as the world's most advanced combine harvester. The all-new LEXION 8000/7000 series pushes the boundaries even further. Featuring the revolutionary APS SYNFLOW HYBRID threshing system at its heart, LEXION 8000/7000 is even more productive, efficient, reliable and easy to operate.

New APS SYNFLOW HYBRID

– 26% bigger treshing drum
– 23% more concave area
– 57% bigger separator drum
– 10% more throughput

CLAAS Harvest Centre

claasharvestcentre.com

CLAAS