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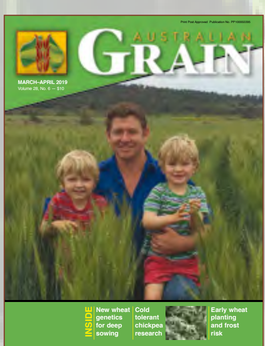
FRONT COVER

COVER CROPS AND SOIL HEALTH



Alex Nixon with sons, Archie (left) and Eddie (right) in their wheat crop at 'Jay-Dee' on the Western Darling Downs, Qld. See article page 29.

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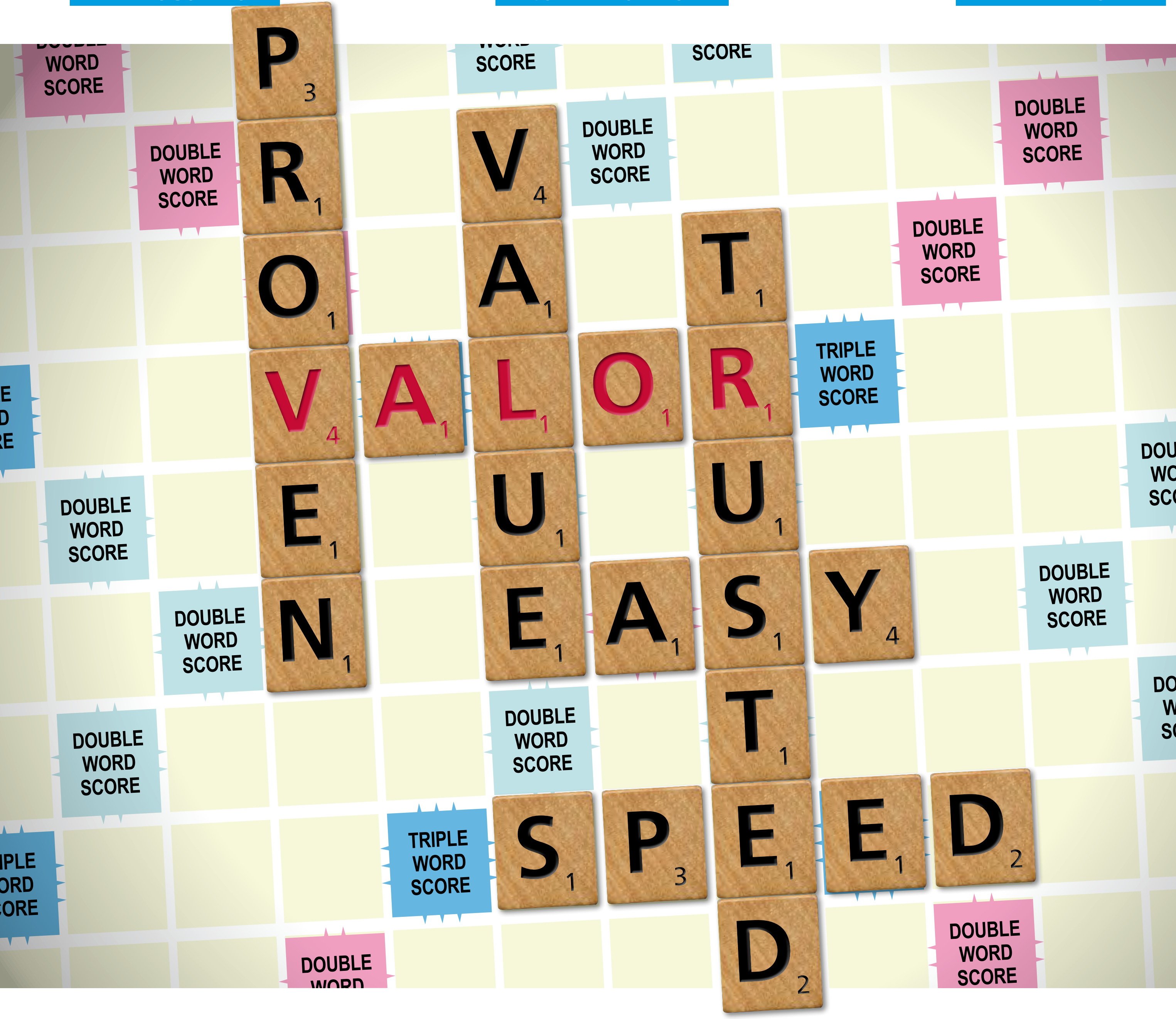
Southern Australia Focus

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

Northern Focus

Covering Northern NSW and Queensland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Editorial… Lloyd O'Connell

HAVING travelled across the country over the past month listening in on scores of excellent Grains Research & Development Corporation Update presentations, it's impossible not to be impressed by the quality and relevance of the leading edge research work being done. Via the Updates, hundreds of world class Australian grain industry researchers have the chance to 'show us what they've got' and within strict time limits. It's a great way to have researchers cleverly zero-in on the main points – a very worthwhile exercise for both listeners and researchers. But these summaries do little to mask the very large reality that agriculture today, and particularly grain and fibre production, are highly complex businesses relying on constant productivity gains to stay profitable.

Undertaking high quality and targeted research – and to have the subsequent results 'consumed' and profitably adopted by farmers – is critical in helping farmers stay in the game. This means research funding organisations, like the GRDC, have an equally critical role in identifying what research is needed and when, and then funding accordingly. By and large, the system works pretty well, but it takes money – and a lot of it.

In the five years to June 30, 2018, annual grain levy contributions by growers and Australian government 'matching' contributions to the GRDC have averaged around $120m and $70m respectively. In turn, GRDC funding of grains industry R&D has averaged $188m per year.

This legislated contribution and R&D funding model, is the envy of researchers and research institutions around the world.

As a result of the drought in the grain producing regions of the eastern states, total national winter and summer crop deliveries for the 2018–19 season are estimated at around 33 million tonnes – or about 30 per cent less than our 5-year average. Consequently, GRDC levy income and Australian government contributions for 2018–19 will also fall.

Depending on the final national crop value, the levies collected from the 23,000 grain businesses across Australia will drop to somewhere around $100m, propped up to some extent by the higher, drought-induced, domestic grain prices. And a very big thank-you is in order here to Western Australian growers who will be contributing more than half of the national levy total. Australian government contributions will also fall by a corresponding amount but the end wash-up will be revenue of somewhere around $150m for the GRDC in 2018–19.

The point is the nationwide R&D levy collection and expenditure model works pretty well for a country where grain production happens across a vast geographic area – and wildly fluctuating yields are par for the course.

Here's hoping the weeks ahead bring some much needed rain to a very dry landscape. This issue contains many articles based on some excellent GRDC Updates presentations, to help you make every post a winner in the coming winter crop.

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In this issue…

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Harvesting wild genes gives crops renewed resistance to disease

■ From The University of Sydney

A GLOBAL alliance of researchers has pioneered a new method to rapidly recruit disease-resistance genes from wild plants for transfer into domestic crops. The technique promises to revolutionise the development of disease-resistant varieties for the global food supply.

The technique – called AgRenSeq – was developed by scientists at the John Innes Centre in Britain working with colleagues in Australia and the US. It has been published in *Nature Biotechnology*.

The result speeds up the fight against pathogens that threaten global food crops, including wheat, soybean, maize and rice, which form the vast bulk of cereals in the human diet.

Professor Harbans Bariana from the Sydney Institute of Agriculture and the School of Life and Environmental Sciences is a global expert in cereal rust genetics and a co-author of the paper.

"This technology will underpin fast-tracked discovery and characterization of new sources of disease resistance in plants," Harbans said.

The current research builds on previous collaborative work done by Harbans with the CSIRO and John Innes Centre. It used two wheat genes cloned by this international team as controls and Harbans conducted the phenotype assessments for the study.

AgRenSeq lets researchers search a library of resistance genes discovered in wild relatives of modern crops so they can rapidly identify sequences associated with disease fighting capability.

Professor Harbans Bariana says the new AgRenSeq technique will help fast-track the development of disease resistant crops.

From there researchers can use laboratory techniques to clone the genes and introduce them into elite varieties of domestic crops to protect them against pathogens and pests such as rusts, powdery mildew and hessian fly.

Dr Brande Wulff, a crop genetics project leader at the John Innes Centre and a lead author of the study, said: "We have found a way to scan the genome of a wild relative of a crop plant and pick out the resistance genes we need: and we can do it in record time. This used to be a process that took 10 or 15 years and was like searching for a needle in a haystack.

"We have perfected the method so that we can clone these genes in a matter of months and for just thousands of dollars instead of millions."

A decade of research reduced to months

The research reveals that AgRenSeq has been successfully trialled in a wild relative of wheat – with researchers identifying and cloning four resistance genes for the devastating stem rust pathogen in the space of months. This process would easily take a decade using conventional means.

The work in wild wheat is being used as a proof of concept, preparing the way for the method to be utilised in protecting many crops which have wild relatives including, soybean, pea, cotton, maize, potato, wheat, barley, rice, banana and cocoa.

Modern elite crops have, in the search for higher yields and other desirable agronomic traits, lost a lot of genetic diversity especially for disease resistance.

Reintroducing disease resistance genes from wild relatives is an economic and environmentally sustainable approach to breeding more resilient crops. But introgression of these genes into crops is a laborious process using traditional breeding methods.

The new method combines high-throughput DNA sequencing with state-of-the-art bioinformatics.

"What we have now is a library of disease resistance genes and we have developed an algorithm that enables researchers to quickly scan that library and find functional resistance genes," said Dr Sanu Arora, the first author of the paper from the John Innes Centre.

"This is the culmination of a dream, the result of many year's work. Our results demonstrate that AgRenSeq is a robust protocol for rapidly discovering resistance genes from a genetically diverse panel of a wild crop relative," Brande Wulff said.

"If we have an epidemic, we can go to our library and inoculate that pathogen across our diversity panel and pick out the resistance genes. Using speed cloning and speed breeding we could deliver resistance genes into elite varieties within a couple of years – like a phoenix rising from the ashes."

This research was supported by the NBI Computing Infrastructure for Science (CiS) group and financed by the Two Blades Foundation, USA to B.J.S. and B.B.H.W.; the Biotechnology and Biological Sciences Research Council (BBSRC) to B.B.H.W. and the BBSRC Designing Future Wheat Cross-Institute Strategic Programme to A.R.B. and B.B.H.W., the Norwich Research Park Translational Fund to B.B.H.W.; the Lieberman-Okinow Endowment at the University of Minnesota to B.J.S.; the Grains Research and Development Corporation, Australia to E.L. and H.B.; the Gordon and Betty Moore Foundation to J.D.G.J. and in-kind support by Arbor Biosciences. ■

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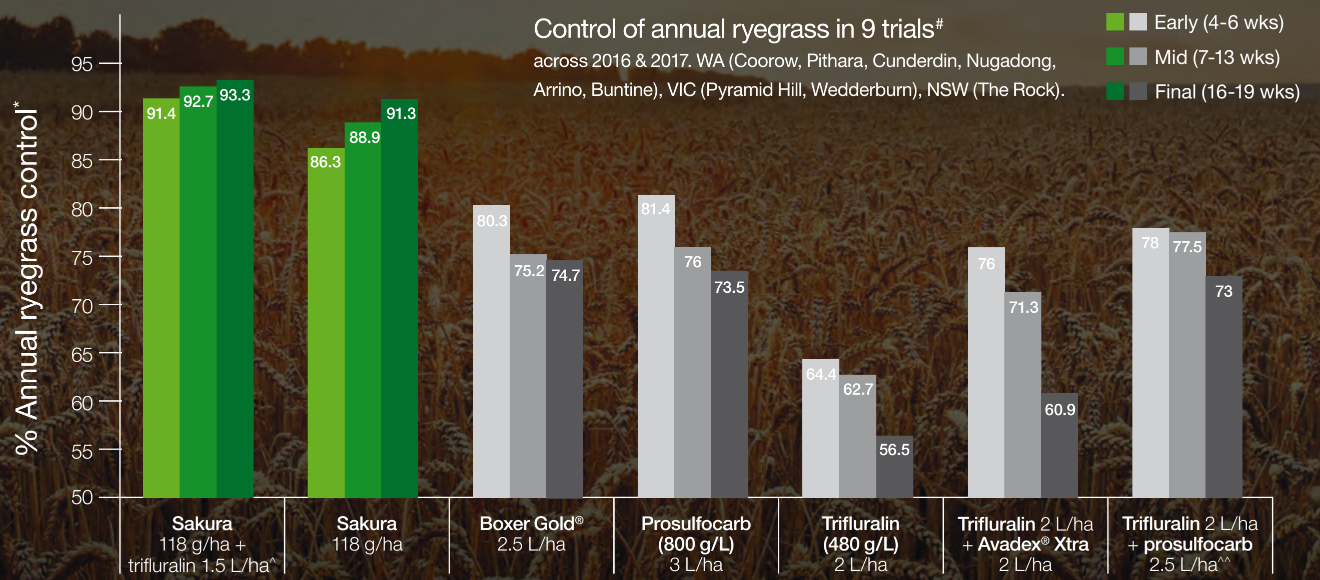

Trial IDs: 16WE05, 16WE06, 16WE07, 16VD12, 16VD13, 16NA11, 17WE32, 17WE07, 17WF07.

* Some trials assessed using weed counts, other control ratings.

\# Two assessment timings only for 16VD12, 16VD13, 16NA11, 17WE07 & 17WF07.

^ Trifluralin (480 g/L) applied at 2 L/ha in trials 16VD12, 16VD13 & 16NA11.

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New genetics to improve wheat establishment with deep sowing

By Greg Rebetzke[1], Wolfgang Spielmeyer[1], Bob French[2], Christine Zaicou-Kunesch[3] and Neil Fettell[4]

AT A GLANCE

- Current Australian wheat cultivars contain dwarfing genes that reduce coleoptile length by 40 per cent. New dwarfing genes are available that reduce plant height but don't reduce coleoptile length.
- A gene increasing coleoptile length was identified and tagged with DNA markers. Breeding lines and DNA markers for new dwarfing and coleoptile length genes have been delivered to Australian breeders for efficient selection of improved crop establishment.
- Deep-sowing studies show that new dwarfing and coleoptile length promoting genes can increase emergence at sowing depths of up to 120 mm without changing plant height.
- Moisture-seeking points coupled with new genetics should reliably allow seed placement and emergence from sowing depths of 100 mm or greater, and/or with warmer soils.

IN Australia's dryland cropping regions, winter crops are typically sown on the first breaking rains. But sometimes these rains are insufficient – and the sub-soil moisture accumulated is too deep – for successful sowing with conventional varieties and planting systems.

The key to good leaf area development for tillering, growth and weed competitiveness is good crop establishment. An ability to establish wheat crops from seed placed 80 mm or deeper in the soil would be useful in situations where the subsoil is moist but the surface dry. Seeding onto moisture at depth extends the opportunities for a greater portion of the cropping program to be sown in the traditional sowing months.

Greg Rebetzke estimates new and improved wheat varieties with longer coleoptile and dwarfing traits, will be commercially available within five or six years.

A separate but concerning issue is the influence of increasingly warmer soil temperatures on reductions in coleoptile length.

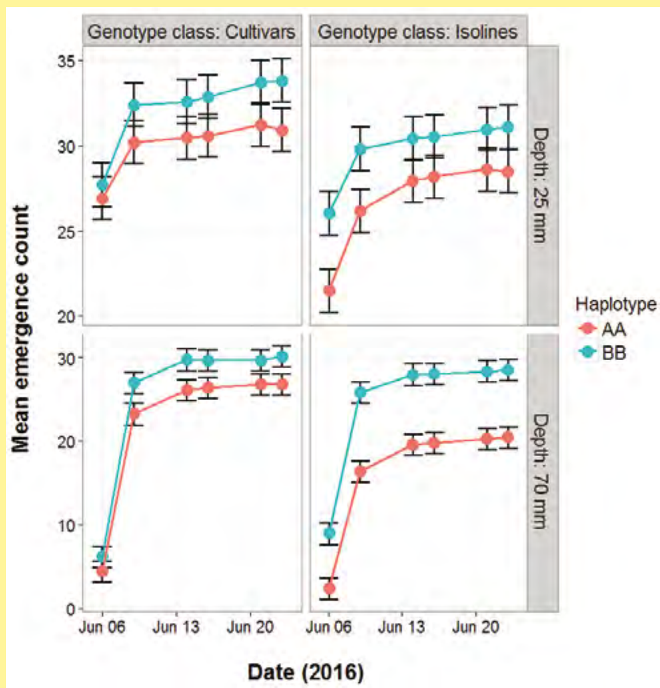
Earlier sowing into warmer soils will reduce coleoptile length by as much as 60 per cent so that a variety such as Mace – with a 75 mm coleoptile at 15°C – will likely have a 40 mm coleoptile at 25°C soil temperature. Some seed dressing and pre-emergent herbicides will reduce this coleoptile length even further affecting establishment.

The 'Green Revolution' Rht-B1b and Rht-D1b dwarfing genes reduced plant heights to reduce lodging and increase grain yields and so are present in most wheat varieties worldwide. Their presence also reduces the length of the coleoptile by as much as 40 per cent. This reduces crop emergence when sown at depths greater than 50 mm, as well as tiller number and leaf size leading to reduced water-use efficiency and weed competitiveness.

New dwarfing genes

A range of alternative dwarfing genes have been identified in overseas wheats with potential to reduce plant height and increase yields while maintaining longer coleoptiles and greater early vigour. Some of these genes (eg. Rht8 and Rht18) have been used commercially overseas but have not been assessed for use here in Australia. We reduced the larger global set of

FIGURE 1: Emergence of wheat cultivars carrying conventional dwarfing genes and tall isolines, Yanco (southern NSW), 2016



Sowing depth treatments were 25 mm and 70 mm. 12 cultivars and 12 isolines were grouped according to the presence of the coleoptile length promoting gene (BB, long coleoptiles) and the lack of the gene (AA short coleoptiles).

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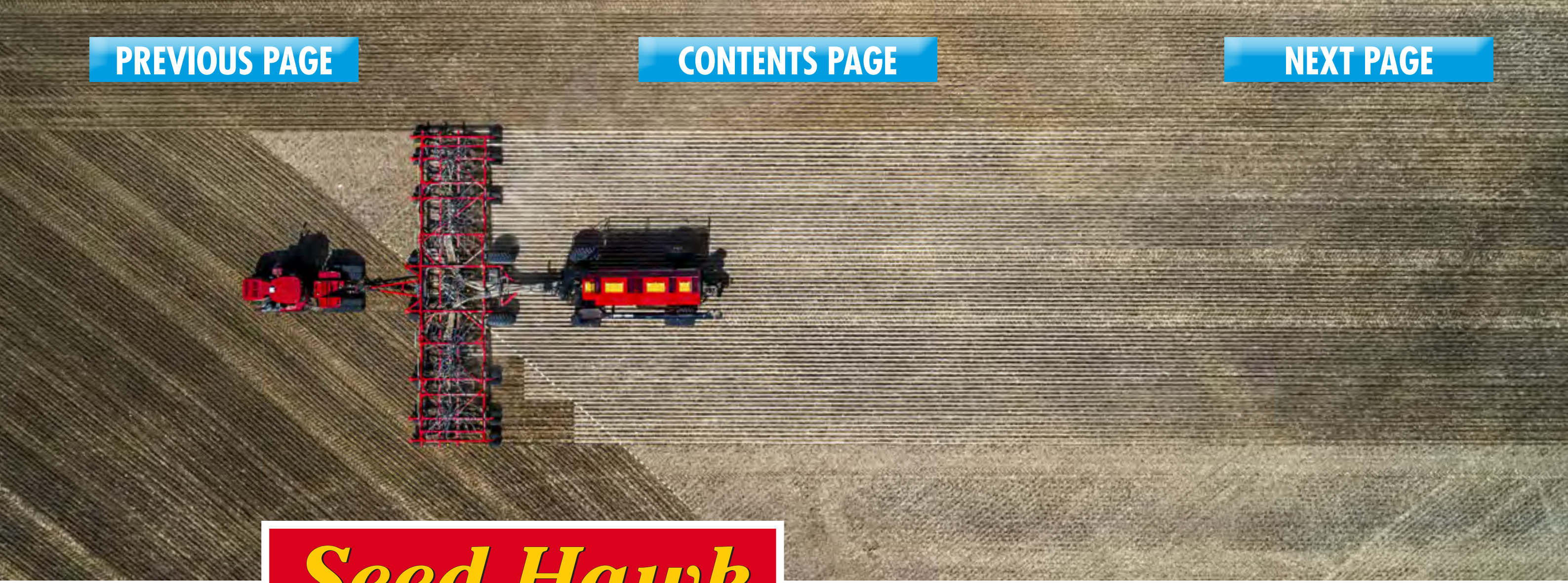

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alternative dwarfing genes to Rht4, Rht5, Rht8, Rht12, Rht13 and Rht18, and then developed linked DNA-markers to assist with breeding of these genes in a commercial breeding program.

Separately, we then bred these genes using conventional and DNA-based methods into the old, tall wheat variety Halberd for testing and disseminating to Australian wheat breeders.

Genes that promote coleoptile growth

While switching to new dwarfing genes will remove the growth inhibition on early growth, there is a need to promote coleoptile growth, particularly in the presence of conventional dwarfing genes.

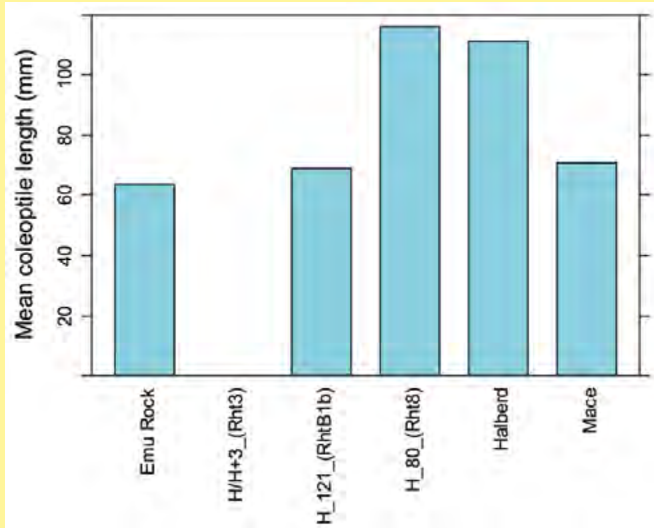
A gene with major effect on coleoptile length was identified in current wheat cultivars. Through a GRDC funded project, we demonstrated that the gene not only increased coleoptile length but also emergence with deep sowing in field trials conducted over three years at Yanco NSW (Figure 1).

The gene was tagged with molecular markers and tested in a wide range of Australian wheat germplasm. We estimated that only 10 per cent of recently released cultivars carry the coleoptile growth promoting gene.

The markers were distributed to Australian breeding companies to assist with the selection and the expected increase of gene frequency in future cultivars. Additional genetic variation for coleoptile length and early growth exists in elite germplasm.

For breeders to take full advantage of this variation, additional genes controlling this trait need to be identified and tagged with

FIGURE 2: Coleoptile lengths of a tall wheat genotype (Halberd) and genotypes with dwarfing genes Rht-B1b (syn. Rht1) and Rht8 in a Halberd background



Emu Rock and Mace are current commercial cultivars with Rht-B1b and Rht-D1b, respectively.

Wheat variety Mace (left) side-by-side with long coleoptile, Mace containing the Rht18 dwarfing gene (right) at Condobolin in 2017.

Wheat variety EGA Gregory (left) side-by-side with long coleoptile, EGA Gregory containing the Rht18 dwarfing gene (right) at Condobolin in 2017.

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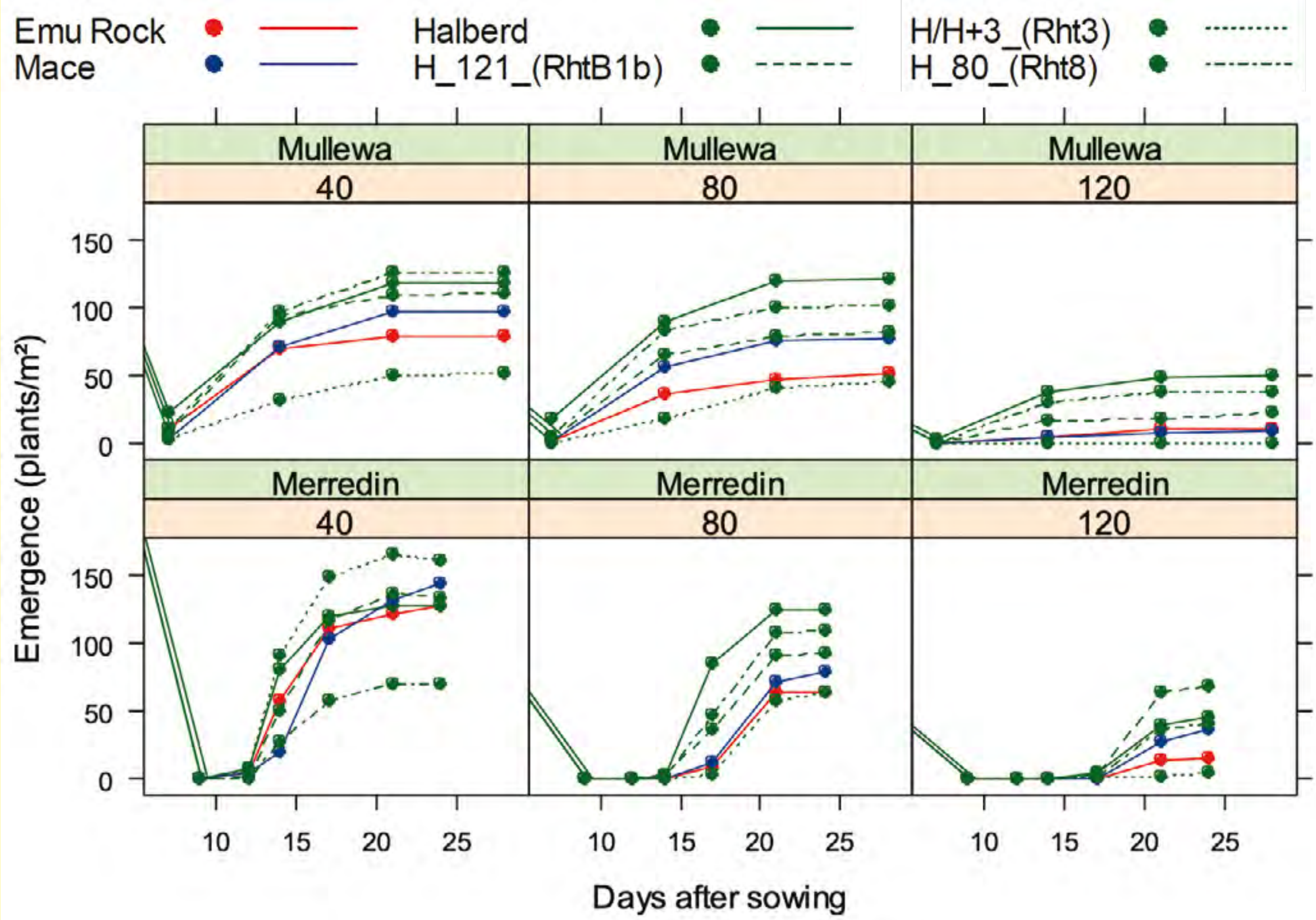
FIGURE 3: Patterns of emergence of wheat genotypes with different dwarfing genes sown at target depths of 40, 80 or 120 mm at Mullewa and Merredin in 2016



markers for efficient selection and combining growth promoting genes for even better performance.

Preliminary sowing depth field studies

Field studies have commenced on these Halberd-based dwarfing gene lines and show that lines containing these genes produced coleoptiles of equivalent length to Halberd (up to 135 mm in length; Figure 2) and established well when sown at 100 mm depth in deep sowing experiments conducted at Mullewa and Merredin (WA) in 2016 (Figure.3).

Grain yields of lines containing the new dwarfing genes were equivalent to the yields of lines containing the commonly used Rht-B1b and Rht-D1b dwarfing genes while previous studies have shown the new dwarfing genes were linked to greater grain yields when sown deep owing to greater plant number with improved establishment.

The most likely useful new dwarfing genes, Rht13 and Rht18, have been bred into a range of current commercial wheats (see photos). Long coleoptile wheat breeding lines in Mace, Scout, Espada, EGA Gregory and Magenta have been delivered to Australian breeders for testing and use in breeding.

If there are no problems with these new dwarfing genes, we may see the first of the long coleoptile wheat varieties in five or six years in NVT testing!

Agronomic opportunities

Although there is real promise in the new genetics, there is significant opportunity in coupling new genetics with existing seeding technologies. Deep sowing is an issue overseas and in the eastern Australian states. The availability of moisture-seeking points commonly used elsewhere should allow the reliable placement of seed at depths of 100 mm or greater. These points produce a slot deep into the soil at the base of which a seed is sown at 10–50 mm depth. That said, further research is required aimed at tools and methods to assess different moisture-seeking points to optimise seed placement at depth across a wide range of soil types.

To sum up

Wheat breeders now have the new dwarfing genes to breed longer coleoptile wheat varieties. Genes that increase coleoptile length have also been identified and tagged with markers.

These genes are expected to play an important role in improving emergence from depth in the presence of conventional dwarfing genes. Matching new genetics with appropriate agronomy and technologies should ensure the emergence and establishment of deep-sown wheats, particularly when sown early to make use of summer rains sitting deep in the soil profile, or to increase sowing opportunities in the traditional months of May and June.

We'd like to acknowledge the support of the GRDC in funding much of the research reported herein. We'd also like to acknowledge the support of the managers of the GRDC's Managed Environment Facilities for their assistance.

Further information: Greg Rebetzke, CSIRO – G.Rebetzke@csiro.au

Authors: 1. CSIRO Agriculture and Food; 2. DPIRD Merredin; 3. DPIRD Geraldton; and, 4. Central West Farming Systems. ■

Where does beer come from?

AT A GLANCE…

- Ale and lager yeast strains were derived from European grape-wine and Asian rice-wine. This finding suggests beer yeast came from the East-West trading along the Silk Route, similar to the spread of domesticated plants and animals.
- The strains also had genes not present in any other population.

FOR thousands of years brewers made beer using specialised strains of the budding yeast *Saccharomyces cerevisiae*. But the historical origins of brewer's yeast are not well understood as brewing predates the discovery of microbes.

A new study published in the journal *PLOS Biology*, led by Justin Fay at the University of Rochester in the US, shows that modern brewing strains were derived from a mixture of European grape wine and Asian rice wine strains.

This finding points to the emergence of beer yeast from a historical East-West transfer of fermentation technology, similar to the transfer of domesticated plants and animals by way of the ancient Silk Route.

The historical origins of any domesticated organism are often clouded by recent migration, gene flow and mixing with other groups. While analysis of ancient DNA has been a boon to reconstructing many historical events, ancient fermented beverages and the microbes used to produce them are not available.

A living relic of ancient ancestors

But many beer strains are known to be polyploid – having more than two copies of their genome – which allows them to remain isolated from other populations and provides researchers with a living relic of their ancestors.

To reconstruct the history of beer strains, the researchers sequenced and compared the genomes of beer strains to a panel of reference strains from around the world. The beer strains formed four related groups:

- Two ales;
- One lager; and,
- One group containing both beer and baking strains.

All of these groups show mixed ancestry from both European grape wine strains and Asian rice wine strains. The strains also contain novel gene variants not present in any other population.

The origin of these novel variants is less clear, but their abundance suggests they were derived from an uncharacterised or extinct population.

A complete reconstruction of the order and timing of events during the evolution of beer strains is difficult since their polyploid genome is not static.

Changes in their polyploid genome have occurred during cell divisions, generating beer strain diversity and likely playing an important role in specialisation to various brewing styles.

Acknowledgements: University of Rochester, USA. This work was supported by a National Institutes of Health, the Rita Allen Foundation, Karl Handelsman, and the National Science Foundation. ■

The physiology and genetics of cold temperatures in chickpeas

■ By Annie Warren, Neroli Graham, Rosy Raman and Kristy Hobson – NSW Department of Primary Industries

AT A GLANCE…

- During flowering, chickpeas are sensitive to cold (<15°C) temperatures which cause flower abortion and results in a delay between flowering and pod onset.
- While early sowing has the potential to reduce the risk of terminal drought, it moves the flowering window to cooler temperatures.
- Current work aims to identify new sources of chilling tolerance for chickpea variety development and to assess the suitability of elite breeding lines for flowering and podding during cool conditions.

CHICKPEAS are well adapted to the northern cropping region in Australia and provide a valuable, economically sound, broadleaf rotation in our farming systems. But various biotic and abiotic factors cause actual yields to fall between 1.7–2.7 tonnes per hectare below potential yield. Cold temperatures during the flowering window can significantly reduce crop yield through delaying and interrupting pod set, causing loss of early pods. In 2016, agronomists estimated yield losses due to cool spring temperatures in north-west NSW ranged from 0.5–0.7 tonnes per hectare.

Chickpeas can suffer damage during the flowering window from both frosts, when temperatures fall below -1.5°C, and 'chilling' where average day temperature does not exceed 15°C. This article will focus on chilling temperatures and their impacts on flowering and podding.

The discussion also has relevance for those 'cooler' cropping regions of Australia where chickpeas may become a very valuable addition to the rotation.

While cool spring temperatures have been historically avoided through late sowing, changes to our farming systems mean there is a greater need for flexibility to sow chickpeas earlier to increase subsequent cropping options and to avoid heat and terminal drought at the end of the season. But this pushes the flowering window to coincide with cooler ambient temperatures.

In north west NSW (Tamworth region), average daily temperatures are not consistently above 15°C until late September and in the cool 2016 season, average temperatures remained below the critical temperature until late October (Figure 1).

In addition, short bursts of cool temperatures occurring weeks after temperatures have begun to rise, can interrupt pod and seed set even in areas that generally experience warm spring temperatures.

The story so far

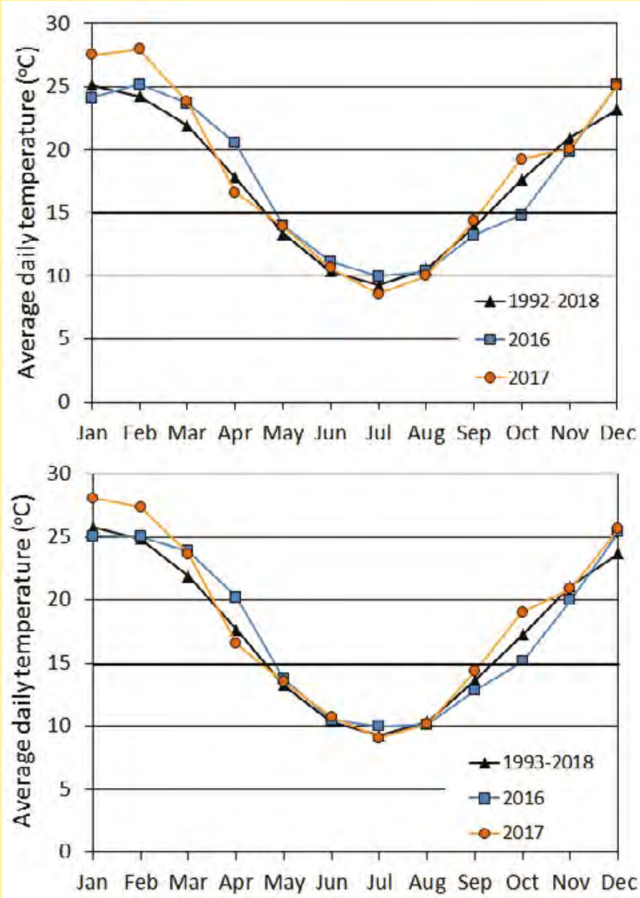
This article outlines current knowledge of chickpea's physiological response to cool temperatures during flowering and what opportunities and challenges exist for improving chilling tolerance through breeding and variety selection.

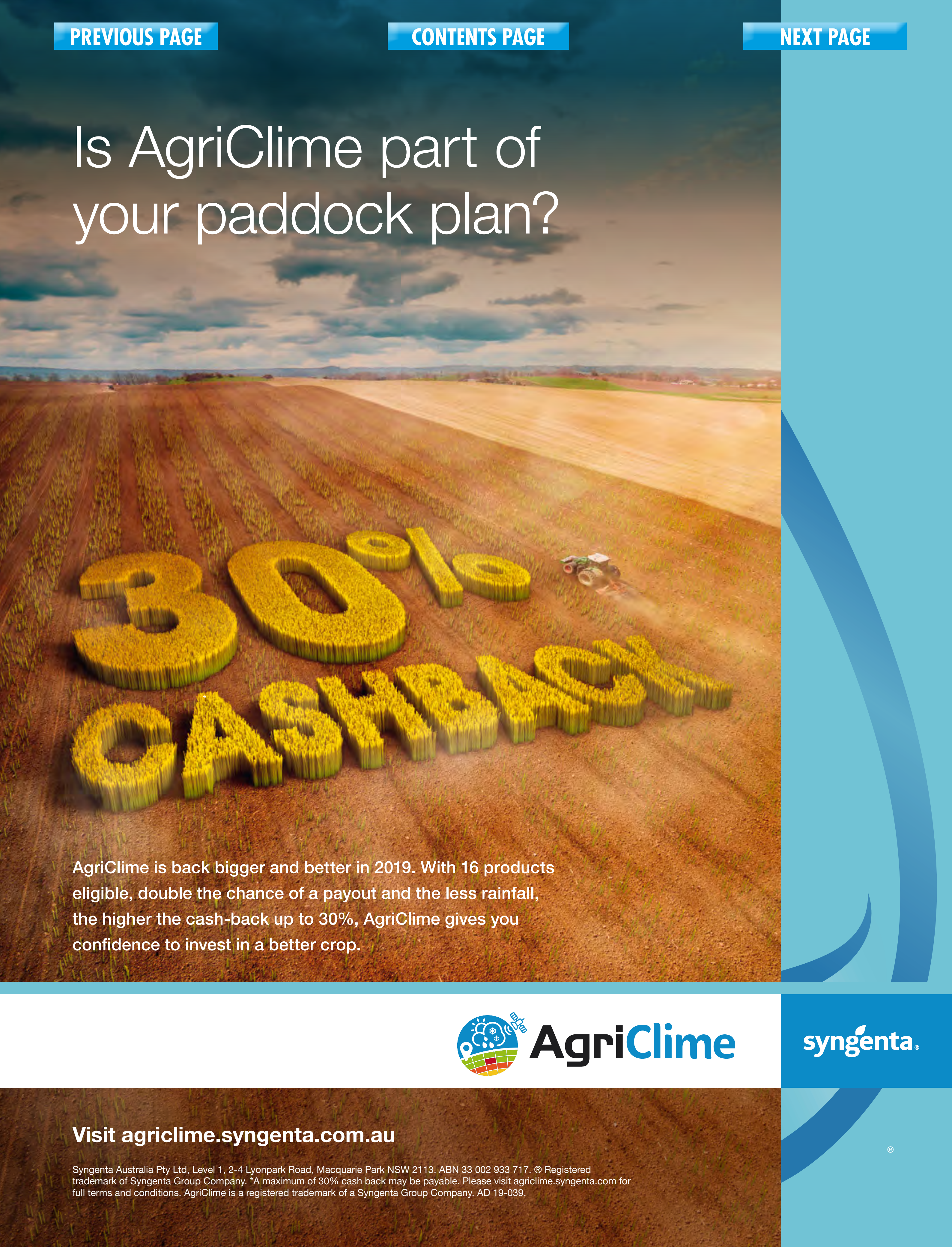
Early sown chickpeas consistently suffer from an extended gap between commencement of flowering and first pod appearance. In ideal conditions, chickpeas will produce pods within a couple of days of flowering. But under cool conditions, the time from the beginning of flowering to the first pods appearing can be more than two months if temperatures remain consistently cool. At Warwick (southern Queensland), Berger *et al*. (2004) found early flowering genotypes took more than 30 days to begin podding when average temperature after flowering did not exceed 14.4°C.

While the length of time between flowering and pod initiation varies across locations and between varieties, the delay in podding remains closely linked to temperature. For every degree drop in average daily temperature between 14 and 10°C, the time between flowering and podding is extended 12 days. During this time plants may continue to produce flowers that are subsequently aborted, or may cycle back into and out of a vegetative state.

While chickpeas may continue flowering under cool conditions, most flowers are subsequently aborted rather than

FIGURE 1: Average daily temperature for Tamworth (top) and Dubbo (bottom) shows cool spring conditions can continue into late September and October

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producing pods. In their work with early sown chickpea in Western Australia, Siddique and Sedgley (1986) found only 38 per cent of flowers carried through to produce harvestable pods among early sown plants, compared to 83 per cent in later sowings. This difference was largely due to flower abortion at low temperature – up to 800 flowers per square metre were aborted when average daily temperature was below 15°C, but no flower abortion occurred once temperature rose above this critical value (see Table 1).

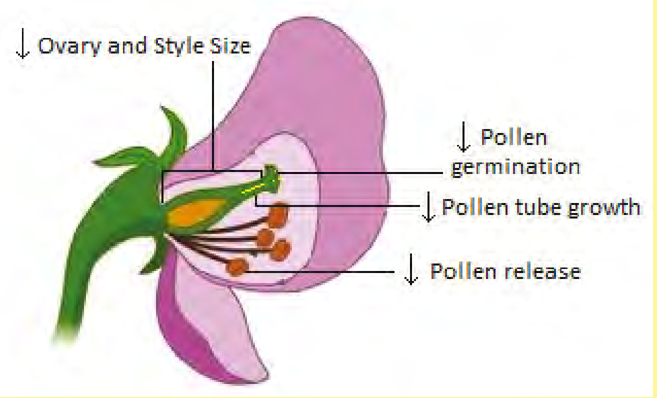
This WA research found that although early sown crops suffer a high flower abortion penalty, this does not necessarily result in inferior yields when compared to later sown crops. Despite high flower abortion, the earliest sown chickpeas still produced the greatest yield. Flower abortion under cool temperatures therefore constitutes a significant lost opportunity, as early flowering plants that also set pods early have the greatest potential to produce high yields.

TABLE 1: Effect of cool temperatures at 50 per cent flowering on flower abortion at Merredin, Western Australia 1983

Planting date (1983)	Mean daily temperature (°C) at 50% flowering	Aborted flowers (per metre)
May 17	12.5	800
May 31	13.6	500
June 14	14.7	200
June 30	16.8	0
July 20	17.7	0

Note: Modified from Croser *et al*., 2003

FIGURE 2: Impacts of cool temperature (<15°C) on male and female reproductive organs of chickpea flowers



Note: Modified from Science Learning Hub – Pokapu Akoranga Putaiao (2011)

On the small scale…

Cool temperatures reduce pollen vigour and ovary and style size of chickpea flowers – alterations that have been implicated in reduced flower fertilisation and increased flower abortion. Pollen development and function is affected by cool temperature from the early stages of pollen production from nine days before anthesis through to pollen tube growth and ovary fertilisation (see Figure 2).

Clarke and Siddique (2004) found cold spells at key points during pollen development at either nine or four to six days prior to anthesis can reduce pod set by 30–60 per cent in susceptible varieties. Cool temperature may also decrease the quantity of pollen reaching the flower stigma due to reduced pollen release from anthers as well as a reduction in ovary and style size. The resulting mismatch increases the difficulty of pollen transfer from anther to stigma.

Once pollen reaches the stigma, pollen germination can be reduced by 30 per cent in susceptible varieties, although some susceptible varieties exhibit normal pollen germination.

Once pollen has germinated on the stigma, pollen tube growth is particularly sensitive to cool temperatures. As a result, far fewer pollen tubes reach the ovary for fertilisation. Srinivasan *et al*. (1999) found while 100 per cent of flowers at an average temperature of 20°C had pollen tubes reach the base of the style, as few as 23.5 per cent of flowers at 10°C had more than 10 fully grown pollen tubes one day after flower opening.

This resulted in fertilisation of as few as 8 per cent of flower ovules. In highly susceptible varieties, no pollen tubes will reach the ovary within 24 hours of pollen germination under cool conditions.

As average day temperature increases from 5 to 25°C, rate of pollen tube growth increases exponentially with only marginal increases in growth rate between 5–15°C. Knowledge about these specific impacts of cool temperatures on chickpea reproduction have led to development of breeding practices such as pollen selection that are better able to target chilling tolerance.

Opportunities for breeding chilling tolerant varieties

While cool temperature during flowering is a relatively new issue for the northern region, it has been identified as yield limiting across southern and western Australia since the early introduction of the crop. As a result, significant work has been conducted in Western Australia to develop chilling tolerant material for breeding programs. Around 15 years ago two chilling

Current Australia-wide research is identifying more cold-tolerant chickpea lines for use in plant breeding programs.

tolerant cultivars, Rupali and Sonali, were developed that could produce pods at 10–12°C and as result pod 20–27 days earlier than existing Western Australian varieties.

But these cultivars have insufficient disease resistance and do not yield comparably to the best yielding varieties in the northern region. In addition, time from flowering to podding can range from 30–70 days at temperatures ranging from 10–12°C. While not suited to northern environments, both Rupali and Sonali have been included in the northern breeding program since 2011 in an attempt to produce well adapted varieties with the ability to set pods at lower ambient temperature.

But the chilling tolerance during flowering and early pod set of progeny derived from either Rupali or Sonali has been insufficient to confer a significant improvement in the ability to set pods early under cool temperatures.

Limited genetic variation within domesticated chickpea restricts further progress in producing cultivars capable of podding at low temperature. But some wild relatives of chickpea show considerably greater chilling tolerance and are able to set pods within 20 days of the beginning of flowering under cool temperatures, compared to the best chickpea cultivar doing so at 30 days.

While chickpea pod production is reduced by three to five times when plants are kept at an average temperature of 10°C compared to 19°C, one particularly promising accession of *Cicer echinospermum* showed no reduction in pod set, setting more than six times the number of pods compared to chickpea at the lower temperature.

There is, therefore, potential to include hybrids between chickpea and its wild relatives in breeding programs to make faster progress towards varieties that produce pods and seeds under suboptimal temperatures.

Where are we now?

Current research aims to identify useful sources of tolerance to suboptimal temperatures that can be used in breeding programs to improve future varieties. In Western Australia, both collections of chickpea and wild relatives are being screened by researchers at CSIRO as potential new sources for chilling tolerance during the early reproductive phase.

Since current methods for identifying chilling tolerant chickpea lines is an expensive and labour-intensive process, several projects are working on developing tools to streamline identification of chilling tolerant breeding lines.

At the University of Western Australia, Dr Janine Croser and her team are working to improve controlled environment screening for chilling tolerance amongst a wide set of chickpea genotypes.

The underlying genetics of early flowering and chilling tolerance in chickpea during flowering is being investigated by NSW DPI at Wagga Wagga and Tamworth to improve knowledge about genetic control of early flowering and podset to potentially work towards developing genetic markers. This project uses a set of recombinant inbred lines formed from hybridisation between domestic chickpea and the wild relative *Cicer echinospermum* which were observed to flower and pod comparatively early in 2016.

In northern and southern NSW, current varieties and elite breeding lines are being assessed for flowering and pod set characteristics under cool spring temperatures through manipulation of sowing date. The aim of this work is to; quantify yield loss from cool temperatures during flowering in the northern and southern NSW regions, expand knowledge of drivers that may improve chilling tolerance, and identify future breeding directions.

In 2018, field trials were conducted to benchmark current varieties and identify breeding lines with potential superior chilling tolerance when compared to existing varieties in northern environments. This data is being processed for analysis.

The research undertaken as part of this project is made possible by the significant contributions of growers through the support of the GRDC. The authors would like to thank them for their continued support.

The authors would also like to thank Helene Davidson and Jessica Simpson for their assistance with data collection and trial management at the Tamworth and Wagga Wagga field sites in the 2018 chilling tolerance work.

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Three of the best!

■ By Ian M. Johnston

"In your opinion, what is the best tractor ever made?"

The question was directed to me by a young bespectacled intelligent looking chap, to whom I had been introduced, at a recent field day. I was delighted to learn that he had apparently discovered the joys of old tractors having read two of my books on the subject. Consequently I realised that his was a serious question, deserving a serious well considered answer.

Having given the matter some moments of contemplation, quite possibly I went down in his estimation when I was obliged to respond by stating that I could not possibly provide a definitive answer. But he later understood when I pointed out to him that over a period of more than a century, there were at least 150 tractor manufacturers scattered across the Americas, Europe and Asia that had produced an incomputable variety of models.

But his question was the precursor for my little grey cells being stirred into action. Okay, to nominate one sole tractor would be ridiculous. But could I narrow the field down to a handful of truly exceptional pioneer machines that influenced the evolution of the farm tractor? This really had me pondering, until I was able to settle on three individual tractors which in my opinion (and only my opinion) could perchance qualify for this distinction.

Interestingly, one is an Aussie.

The Wallis Bear

Whilst carrying out research in the USA for a one of my earlier books, I visited the prairie town of Bluffton, Ohio, for the purpose

The only remaining Wallis Bear – owned by Fred Schmidt of Blufftown, Ohio. (Photo IMJ)

This photo of me standing beside the Bear gives an idea of its immensity. **(Photo M. Daw)**

of calling on Fred Schmidt. Fred was a well known tractor identity in Ohio, as he was the proud custodian of the world's only surviving Wallis Bear, which had actually been in his family since 1962.

When the doors of his barn were rolled open, I confess to being stunned as my gaze swept across a range of around a dozen pristine Wallis tractors, before focussing on the massive and technically amazing Bear.

According to the majority of tractor book scribes, The Wallis Tractor Company of Cleveland, Ohio, was created in 1902, under the control of H.M. Wallis, a relative of Jerome Increase Case. Frankly I dispute the company name, as the term 'tractor' did not come into usage until 1906. Certainly a manufacturing company was formed by H.M. Wallis, but I suggest under a different title.

But let me not descend into a battle of semantics.

The Wallis Bear No. 1 was released with little fanfare in November 1902. It is known that a mere nine units were produced over a period of the next nine years. Fred Schmidt's example is No. 3.

So what is so special about the Wallis Bear? It is a case of where do I start!

The tractor was equipped with – turning brakes, power steering, spring loaded clutch, coil spring front suspension, force feed lubrication by gear driven pump, all speed governor, fully enclosed transmission, four cylinder engine with 7.5 x 9 inch bore and stroke of 1480 cubic inch displacement. (These specs could almost relate to a modern day tractor).

All that in 1902, a time when the few tractors in existence mainly featured exposed transmission gears, cone clutches, cart brakes, single or twin cylinder crude engines, navvy type chain steering, oxen fat lubrication and no governor.

Fred started the engine for me with very little effort, using just one pull of the rear located crank handle. I was impressed by how smoothly the massive engine ran with no noticeable vibration.

For the record, Wallis produced an extensive range of 'conventional' tractors, until the firm was acquired by The J.I. Case Plow Works in 1915.

Definitely, Fred Schmidt's Wallis Bear ranks in my mind as being one of the greatest of all artefacts in a classic tractor collection, and certainly a contender for being rated as one of the top three tractors of all time.

Caldwell Vale

The story of the Caldwell Vale has its beginning in Adelaide, when in 1907 the brothers Felix and Norman Caldwell registered a patent for a revolutionary transmission design, which described a means of delivering power in equal proportions to all four wheels of a vehicle.

In order to prove the efficiency of their design, they constructed a rudimentary six metre long chassis consisting of two parallel steel girders supported on an axle and iron wheels at either extremity. A massive 30 hp twin cylinder McDonald water cooled engine was centrally mounted and provided power to all four wheels and (remarkably) a four wheel steer mechanism.

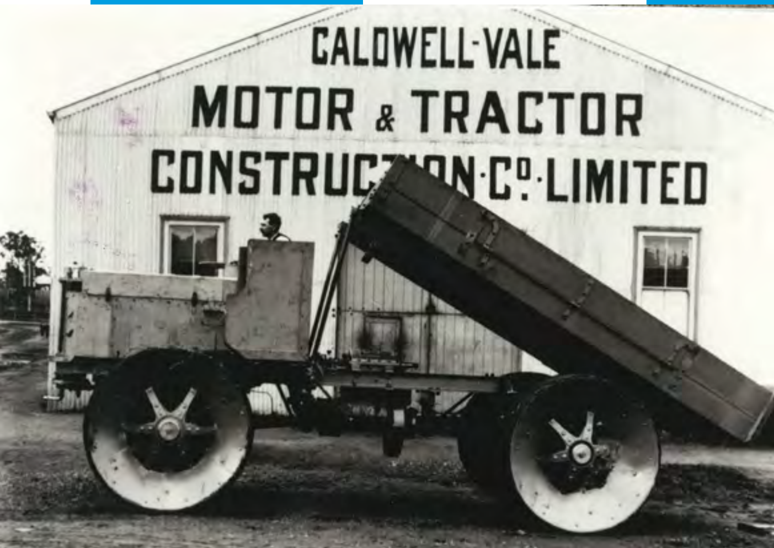
A custom designed 10 disc plough was attached to the underside of the contraption, which could be raised and lowered by means of a cleverly conceived power-lift system.

The overall design of the Caldwell brother's invention was unprecedented in 1907 and was brought to the attention of the dignitaries of The Roseworthy Agricultural College of South Australia. A demonstration was arranged, the results of which created a sensation to the amazed agriculturalists, who were accustomed to ploughs being pulled by teams of plodding draught horses.

Henry Vale, a Sydney based financier, learning of the potential of the revolutionary motorised plough, offered the brothers financial backing to establish a tractor manufacturing plant at the Sydney suburb of Auburn. Accordingly, in 1910 the firm of Caldwell Vale Motor and Tractor Construction Company commenced business at Park Road, Auburn, telephone number Rookwood 114 – a two hour drive in a sulky from Sydney Central.

A range of sophisticated four wheel drive tractors followed, commencing with a three ton 40 hp with four equal wheels, capable of hauling an eight furrow mouldboard plough, set to a depth of 10 inches, at three mph. It is interesting to note that this

A historic photo of a Caldwell Vale operating in Central NSW. **(Photo IMJ archives)**



A 1912 photo of a Caldwell Vale outside the Auburn premises. (Photo IMJ archives)

An 80 hp 1910 Caldwell Vale restored by the late Fred Schuster. (Photo IMJ)

extraordinary performance would be beyond the capabilities of a modern 40 hp tractor!

This was followed by an 80 hp heavy duty range, each with four wheel drive, power steering, four wheel steer, and four wheel brakes. The engine, designed and built by Caldwell Vale (as were all their tractor engines) was of the 'square' configuration, i.e. identical bore and stroke. This again emphasises the ingenuity of the designers, as 'square' engines did not really come into prevalence until around half a century later!

A number of the 80 hp units were employed dragging a line of wagons loaded with supplies, to outback stations. The top speed of the tractors was a dependable six mph. This may at first sound painfully slow, considering the distances to be travelled.

But in practice a Caldwell Vale tractor could haul a 50 ton load at double the speed of a team of oxen or horses, and continue so doing 24 hours a day. But there was one snag! Fuel consumption of the big 11 litre engine equated one mile per gallon!

Certainly, this amazing Aussie tractor has to be considered in the class of one of the top three most innovative tractors of all time.

An Ivel at work near Leeton, NSW, around 1910. (Photo IMJ archives).

Ivel

Agriculture in Britain is, and always has been, different to that in North America and Australia. The small acre fertile arable farms of Britain, with their rich deep soils, were traditionally worked with either single or two horse implements. This method of farming differed significantly when compared to the shallow soiled broadacre grain belts of Australia and the Americas, which required the employment of either large teams of horses or mules, often numbering up to 20 animals, or as mechanisation took hold, large heavyweight tractors.

These early heavyweight tractor designs were greatly influenced by the huge steam powered traction engines which they replaced. The philosophy of the era was that 'big was beautiful'. This thinking is evidenced by the two tractors already examined – the Wallis Bear and the Caldwell Vale.

Dan Albone was born and reared in the tranquil Bedfordshire village of Biggleswade, through which the river Ivel meanders. His passion was cycling and at age 13 he designed and built a bicycle, complete with suspension, upon which he entered and won numerous cycle race events.

In 1880, on his twentieth birthday, he founded The Ivel Cycle Works. But his interest was not restricted to cycles, as he harboured a fondness for the agricultural activities which surrounded his rural village. Gentle Suffolk Punch heavy draught horses were the choice of the farmers, for pulling the single furrow mouldboard ploughs commonly in usage.

Following the Industrial Revolution, mechanisation was appearing everywhere throughout Britain and Dan Albone believed it could also be applied to, and benefit, local farmers.

In 1902 he filed a patent for a farm vehicle powered by an internal combustion petrol engine and opened a new business named Ivel Agricultural Motors Ltd. The Ivel tractor was born!

An 1903 Ivel, restored by Norm McKenzie, being admired at a field day. (Photo IMJ)

A view of Norm McKenzie's Ivel illustrating the drive mechanism. (Photo IMJ)

Unlike the first American and Australian tractors, the Ivel was a compact and relatively lightweight machine that could replace two Suffolk Punch horses. It was, in fact, the world's first tractor ideally suited to the British and European farming methods. It attracted an immense amount of interest and indeed won several gold medals at agricultural shows.

The tricycle configured design had the single steer wheel at the front of the tractor with two large steel driving wheels at the rear. The engine utilised initially was a twin cylinder eight hp Payne, but was replaced in 1906 with a more sophisticated French made water cooled 10 hp Aster, featuring twin horizontally opposed cylinders and a large evaporative water tank. The transmission was connected by a heavy duty belt and consisted of a cone clutch and a single forward and reverse gear.

Between 1902 and 1920 around 500 Ivel tractors were produced, many being exported to distant parts of the world, including Australia.

The reason I have included the Ivel in my selection of tractors that qualify as being "Three of the Best", is the fact that Albone did not let his creation be influenced by the direction of other designers, who were focussed on heavyweight tractor development .

As a consequence the Ivel proved to be the forerunner of the multitude of modern tractors such as Fergusons, David Browns, Fordson Dextas, and so on.

It is interesting to note that Dan Albone introduced the Benz powered Ivel motor car in 1898 and the Ivel motor cycle range in 1901. He died in 1906, aged 46 years. ■

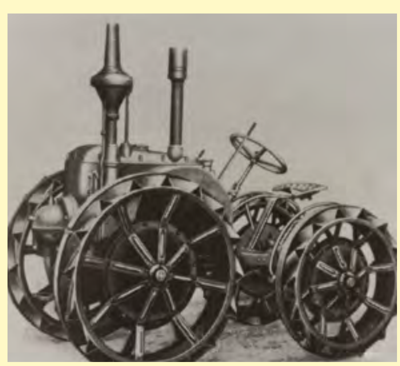
IAN'S MYSTERY TRACTOR QUIZ

Question: Can you identify this 1925 four wheel drive articulated tractor?

Clue: It is European.

Degree of difficulty: Any tractor historian would identify it in a flash!

Answer: See page 48.



WEED smart
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ASK AN EXPERT – DOES DIVERSITY HELP WITH WEED CONTROL AND HERBICIDE RESISTANCE?

With Ken Flower, Senior Lecturer, The University of WA School of Agriculture & Environment

BACK in 2006, the WA No-Tillage Farmers Association (WANTFA) wanted to investigate the long-term effect of different farming 'philosophies' and residue management on factors affecting crop profitability, including yield, moisture storage, soil nutrients, weeds and disease.

With co-investment from the GRDC, WANTFA engaged Dr Ken Flower, now a senior lecturer at the UWA School of Agriculture and Environment, to establish and monitor a large-scale, long-term farming systems trial.

"This trial has been running for 12 years now and we have been able to measure the effect of four farming systems with different levels of crop diversity in three-year rotations," says Ken.

"The least diverse system is monoculture wheat, next is continuous cereal rotation, third is a cereal/legume/brassica rotation. The fourth system is farmer-designed and follows a cereal/cereal/break crop (or fallow) rotation."

Dr Ken Flower, UWA has been managing a long-term farming systems trial in Cunderdin WA that is demonstrating how diversity in weed control tactics is essential across any crop rotation cycle.

"An important feature of this trial is that there is built-in flexibility in the design that allows us to respond to any build up in weeds. Every three years we decide on the best combination of crops, varieties and available technologies that are compatible with each farming philosophy treatment for the next 3-year rotation."

Having now completed 12 seasons of the trial on an alkaline red sandy clay loam at Cunderdin (160 km east of Perth), the weed pressure is considerably higher in the monoculture wheat treatment while all other treatments have allowed more diverse

The recent addition of harvest weed seed control (narrow windrow burning in this case) has been very effective in driving down weed numbers, particularly in high risk rotations.

The rotations since 2010 have been:
- **Cereal rotation – wheat/wheat/barley;**
- **Diverse rotation wheat/chickpea then albus lupin/RR canola;**
- **Monoculture wheat; and,**
- **Farmer rotation – wheat/barley/fallow.**

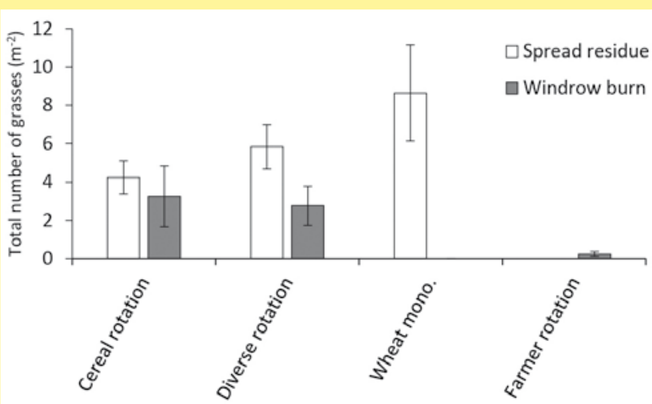
and effective weed control programs to be implemented using herbicide mixing and rotation, crop tolerance technologies and harvest weed seed control.

Has increased crop diversity helped control weeds?

Short answer: Yes, with more weed control strategies available in a diverse system it is easier to keep weed numbers low.

Longer answer: In the monoculture wheat, it didn't take long for grass weeds to build up in numbers. The main weed species at the site have been wild oats, brome, rye and barley grasses. There are limited herbicide options in the monoculture, except rotating between registered MOA for wheat, although the recent inclusion of Clearfield wheat in the rotation has been very effective. The wheat variety sown has changed over time to reflect improvements in plant breeding.

FIGURE 1: Total number of grass weeds in 2017 measured about six weeks after crop emergence in the cereal rotation, diverse rotation, wheat monoculture and farmer rotation



Windrow burning started after 2010 harvest.
Note the monoculture has no windrow burning subplot and the farmer rotation has only windrow burning since 2010.

In the continuous cereal treatment, including barley as a more competitive crop at least once every three years has helped keep weed numbers lower.

Were broadleaf crops an effective weed control measure in the more diverse treatments?

Short answer: Yes and no.

Longer answer: Roundup Ready canola has been a very effective tool in the diverse farming systems. The legumes have been a weak link in the rotation in terms of weed control. Narrow leaf lupins were initially used in the legume phase and then the switch was made to field peas. Field peas have the distinct advantage of being sown at a later date, allowing better knockdown weed control after the breaking rain but before seeding. Chickpea and albus lupin have also been used, but it has not been possible to overcome the tendency for weeds to build up in the legume phase.

The fallow in the farmer-designed rotation has been particularly effective at reducing weed numbers, but may have an impact on soil organic carbon, which we are looking at.

Has herbicide resistance evolved in any of the treatments since the trial started in 2007?

Short answer: Herbicide resistance testing has not been conducted during the trial.

Longer answer: There was known resistance in annual ryegrass to Group A herbicides so this has been taken into account when planning herbicide mixes. Throughout the trial researchers and WANTFA farmers have responded to weed pressures with the aim of keeping numbers low.

Did introducing narrow windrow burning (NWB) impact on weed numbers?

Short answer: Yes. The introduction of NWB has provided a distinct reduction in weed numbers in all treatments.

Longer answer: Narrow windrow burning was introduced after the 2010 harvest mainly as a means of providing a low-stubble and high-stubble comparison for assessing soil moisture effects. One of the original research questions at the trial site was 'how much stubble is optimal for profitable crop production?'. But there was not sufficient difference between the treatments so the decision was made to split the plots using narrow windrow burning to provide a low-residue treatment within each of the four farming systems.

Adding a non-herbicide weed control tactic to the trial design brought an immediate reduction in the NWB plots within each treatment. As expected with NWB over time, nutrients are concentrated in the windrow, creating uneven crop growth. This is exacerbated in a controlled traffic farming system, as the stubble in the narrow windrow is placed in the same position each year. ■

HOW TO ASK A WEEDSMART QUESTION

Ask your questions about the weed control in different farming systems 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.

Leaf stage and controlling glyphosate-resistant tall fleabane

■ By Bhagirath S. Chauhan[1]

AT A GLANCE…

- A population of tall fleabane has been found highly resistant to glyphosate.
- Herbicides provided better control when applied at the four-leaf stage of tall fleabane (compared to 14-leaf stage).
- Saflufenacil was the most effective herbicide and could be included in the double knock herbicide option.
- Control herbicide-resistant populations at an early stage.

TALL fleabane (*Conyza sumatrensis*) is an erect annual broadleaf weed species, which can reach up to two metres in height. It has a tap root system. The flowers are greenish white, which produce fluffy seeds. Seeds are spread by wind, which makes it hard to implement management strategies.

Tall fleabane is a major weed of fallows and competes for soil moisture in fallow as well as crops. Recently, glyphosate and paraquat resistant biotypes have been reported from the northern region of Australia. Such resistance reports suggest that there is a need to evaluate performance of different herbicides for the control of fleabane. Generally, herbicide efficacy is reduced when applied on large weed plants.

But such information is not available for tall fleabane. This article reports on research to evaluate the efficacy of different post-emergent herbicides on tall fleabane when applied at 4 and 14-leaf stages.

Bhagirath Chauhan with tall fleabane in the background. Weed growth stage is very important when applying herbicides.

What was done?

A suspected glyphosate-resistant population of tall fleabane was collected from a fallow field near Dalby. Two pot experiments were conducted in the weed science screenhouse facility of the University of Queensland, Gatton. Pots (20 cm diameter) were filled with potting mix and seeds were planted on the soil surface. After emergence, 8 plants were kept per plot.

Herbicides were applied using a Research Track Sprayer that delivered 108 litres per hectare spray solution. TeeJet

PREVIOUS PAGE CONTENTS PAGE NEXT PAGE

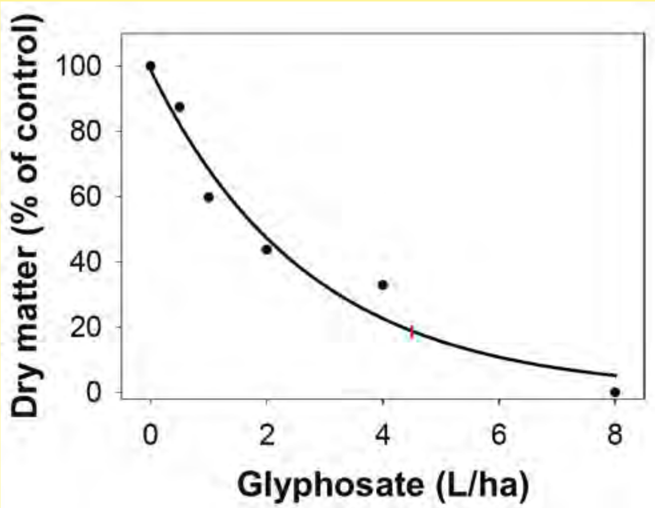
110015 nozzles were used in the sprayer. At three weeks after application, plant survival was assessed with surviving plants harvested and oven dried for three days at 70°C for dry matter determination.

Survival and dry matter data were converted to a percentage of the non-treated control treatment.

Experiment I

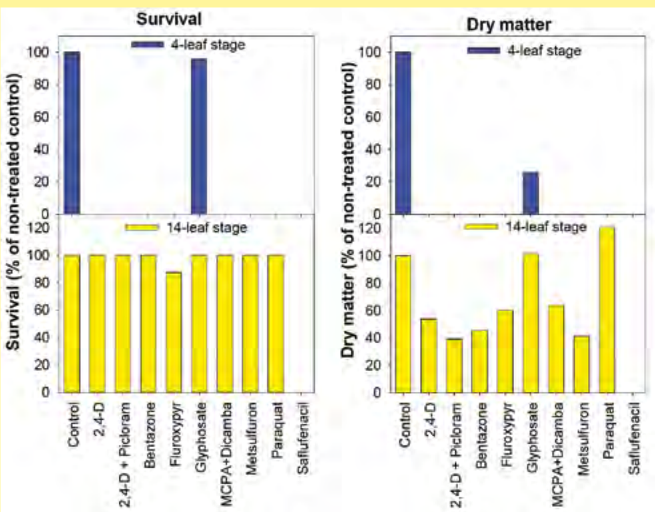
To evaluate the resistance level, tall fleabane plants were sprayed with glyphosate at the four to five leaf stage. Glyphosate (450 g/L) rates were 0.5, 1.0, 2.0, 4.0 and 8 litres per hectare. There was a non-treated (0 litres per hectare glyphosate) control treatment. Each treatment was replicated three times.

FIGURE 1: Effect of glyphosate (L/ha) dose on the dry matter reduction (% of the non-treated control treatment) of tall fleabane



The blue and red lines show the doses required to reduce 50 and 80 per cent dry matter (versus non-treated control).

FIGURE 2: Effect of different herbicide treatments on survival (% of the non-treated control treatment) and dry matter (% of the non-treated control treatment) of tall fleabane when applied at four-leaf (blue bars) and 14-leaf stage (yellow bars)



Experiment II

In this experiment, tall fleabane plants were sprayed with different (registered and unregistered) herbicide treatments at 4 (3 cm in diameter) and 14-leaf (12–14 cm in height) stages. Herbicide treatments and their doses are shown in Table 1. There was a non-treated control treatment for each leaf stage.

What was found?

Experiment I

The tall fleabane population was found highly resistant to glyphosate (Figure 1). About 95 per cent of plants survived the rate of 4 litres per hectare glyphosate. A rate of 1.8 litres per hectare glyphosate was required to reduce 50 per cent dry matter of the non-treated control plants. To reduce 80 per cent dry matter, glyphosate at 4.3 litres per hectare was required.

Experiment II

More than 95 per cent of plants survived following the application of glyphosate at the four-leaf stage (Figure 2). But the dry matter of the glyphosate treated plants was only 26 per cent of the non-treated control treatment. These results suggest that the treated plants survived the herbicide application but their growth was suppressed. Other herbicides applied at the four-leaf stage had no surviving plants.

The results were very different when herbicides were applied at the 14-leaf stage. Only saflufenacil provided 100 per cent kill of the plants. Fluroxypyr-treated pots had 88 per cent plant survival and other herbicides had 100 per cent survival. At this stage, metsulfuron and 2,4-D + picloram provided about 60 per cent reduction in the dry matter. Glyphosate and paraquat did not provide any suppression in the dry matter.

This tolerance to most herbicides might be due to the ability of the plants to rapidly metabolize the herbicides.

To sum up

The results of this study clearly highlight the importance of leaf stage when applying herbicides. Growth stage becomes very critical when the target is a glyphosate-resistant weed. The 4-leaf stage was found most susceptible to the tested herbicides.

But in a field situation, it is very difficult to spray herbicides at or before this leaf stage. So there is a need to evaluate the effect of increased herbicide rates, herbicide mixtures and double knock herbicides. Saflufenacil (Sharpen) was the most effective herbicide. This herbicide could be included as a potential second knock option for the control of tall fleabane.

1. Associate Professor, QAAFI, University of Queensland, Gatton. ■

TABLE 1: Herbicide treatments used in the study

No.	Treatment	Rate/ha
1	Control	—
2	Amicide Advance 700 (2,4-D)	1.5 L
3	Tordon 75-D (2,4-D + picloram)	1.0 L
4	Basagran (bentazone)	2.0 L
5	Starane Advanced (fluroxypyr)	0.3 L
6	Glymount (glyphosate)	1.5 L
7	Kamba M (MCPA + dicamba)	1.0 L
8	Associate (metsulfuron methyl)	5 g
9	Nuquat 250 (paraquat)	2.0 L
10	Sharpen (saflufenacil) + 1% Hasten	12 g

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Dry weather doesn't deter crown rot management

MANAGING crown rot has become virtually second nature to growers in northern New South Wales and Queensland over the past 10 years.

It's a risk most growers now routinely factor into key management decisions on crop and variety selection, sowing time and planting configuration in a bid to avoid potential yield losses which can be more than 50 per cent if not managed.

The crown rot fungi are stubble borne fungal pathogens that can affect all winter cereals by restricting the flow of water and nutrients to developing heads when moisture or heat stress occurs during the critical grain filling stage. This can result in pinched grain or heads with no grain – otherwise known as 'whiteheads'.

Dry conditions in 2018 heralded a significantly smaller wheat and barley plant with generally reduced biomass and yield production. But experts are still expecting most growers to remain on crown rot alert in recognition that vigilance is the key to management over the longer term.

NSW Department of Primary Industries (DPI) senior plant pathologist Dr Steven Simpfendorfer said crown rot inoculum levels were a function of biomass/number of tillers produced, both of which tended to be reduced in a dry year, and the percentage of plants infected by the pathogen. Hence, inoculum levels, while not increasing as much as in a wetter year, are still maintained in lower yielding cereal crops in drier seasons.

"A potentially bigger issue in a dry year is reduced stubble decomposition due to lack of moisture which restricts displacement of crown rot inoculum, especially in standing cereal stubble, even if a break crop was grown in 2018," Steven said.

"Effective crown rot management is a long term commitment. It hinges on using a combination of tactics including break crops to reduce inoculum levels in paddocks, inter-row sowing to limit infection levels, fallow management, cereal crop and variety choice, sowing time and addressing other sub-soil or soil-borne constraints such as sodicity and root lesion nematodes.

"So, it's important that growers remain vigilant and opt for Predicta B testing ahead of this year's winter crop plant so they can make informed decisions about crop and variety selections and tweak their longer term disease management programs if necessary."

Predicta B is a DNA-based soil test that has been successfully used by growers and advisers for years to assess crown rot inoculum levels and guide crop/variety and paddock selection, long term disease management and the identification of other soil-borne diseases or root lesion nematode issues.

NSW Department of Primary Industries (DPI) senior plant pathologist Dr Steven Simpfendorfer is encouraging growers to undertake Predicta B testing ahead of the winter crop plant so they can make informed decisions about crop and variety selections and tweak their longer term disease management programs if necessary. (PHOTO: GRDC)

Continually evolving

The testing is continually evolving to support growers across different regions. A test for inoculum levels related to Ascochyta blight of chickpeas and two tests for beneficial Arbuscular Mycorrhizal Fungi (AMF), which when at low numbers cause long-fallow disorder, were added to the northern region options in 2018.

It's an important research investment for the GRDC and is commercially available to growers through the South Australian Research and Development Institute (SARDI).

Testing soil samples with added stubble/plant residue before planting is the most effective way to assess the risk of crown rot within individual paddocks.

For results to be accurate, Predicta B requires a dedicated sampling strategy and is not a simple add on to a soil test.

Sampling recommendations:

- Collect two cores of one centimetre diameter and 15 centimetres deep from each of 15 different locations within the target paddock or production zone.
- Samples may be taken to a depth of 30 cm if growers are concerned about *Pratylenchus thornei* detection.
- If using a larger diameter core or coring to 30 cm, take fewer cores per location.
- Take soil cores from along/in the rows of the previous cereal crop if still visible and retain any stubble collected by the core. Most soil-borne pathogens are concentrated under the rows of the last cereal crop.
- If the rows cannot be seen, take the cores at random.
- Add two pieces of cereal stubble (or grass weed), if present, to the sample bag at each of the 15 sampling locations to improve the detection of crown rot.
- Each piece should be a single dominant tiller from the base of different plants and include the crown to the first node. Discard material from above the first node.
- Maximum sample weight should not exceed 500 grams.

Crown Analytical Services (CAS) is the service co-ordinator for the northern region Predicta B test and can provide northern growers and advisors with bags, soil corers, protocols and procedures for sampling as well as an interpretation of results once tests are completed.

Predicta B kits can be obtained from CAS by contacting 0437 996 678 or email crownanalytical@bigpond.com or for more information on the Predicta B tests visit the SARDI website *www.pir.sa.gov.au* ■

Quantifying nutrient removal this harvest

■ By Bede O'Mara, agronomist, Incitec Pivot Fertilisers

A NUMBER of (fortunate) growers are now harvesting summer crops in northern New South Wales and Queensland, after another tough summer cropping season.

While it is not traditionally a time to consider nutrition plans, harvest time does present an easy opportunity to get some valuable data. Not by soil testing – which is unlikely to provide insights yet for the next crop when soil moisture levels are so low – but by grain nutrient testing.

Grain nutrient testing helps growers extract information from their crop that may be used to better quantify nutrient removal from the paddock, assess the performance of their summer crop nutrient program and start to plan fertiliser programs for the coming season.

Nutrient testing is available on all grains and is a simple way to get a head start on future seasons.

Growers and advisers have been using yield results for many years to estimate nutrient removal, but these rely on average removals. But it is difficult for published averages for grain nutrient removal numbers to be meaningful for crop nutrition programs, especially when the seasons have been anything but average.

Consider the differences in yield, grain quality and nutrient levels seen in these grain tests after three different years in crops on trials sites at the Darling Downs, western Downs and in northern NSW (Table 1).

The nitrogen, phosphorus, potassium and zinc values have varied due to the seasonal conditions and protein, while the sulphur levels have been fairly consistent over the years.

The sorghum grain test results revealed wide variations in nutrient removal levels depending on the season.

It might be easy to just use an average figure and assume that 18 kg of nitrogen is being removed per tonne of sorghum grain, but grain test results (Table 1) show the actual nitrogen removal figure could be up to 100 per cent higher.

Grain nutrient tests have also revealed that the rate of potassium

Given the string of wildly variable seasons over the past 24 months, Bede O'Mara, agronomist with Incitec Pivot Fertilisers, says the best way to manage nutrition is by gathering some hard data from grain nutrient tests and soil tests.

TABLE 1: Sorghum grain nutrient test results from trial sites in northern NSW and southern Queensland

	Trial data	2017–18	2016–17	2015–16	Published data	
	Mean grain yield (t/ha)	*4.56*	*7.52*	*3.15*	Average removal*	Range
	Grain protein %	*13.9*	*11.6*	*14.5*		
N	(kg N/t grain)	36.6	18.6	23.2	18.0	9–26
P	(kg P/t grain)	4.0	5.6	2.9	3.4	1.4–4.0
K	(kg K/t grain)	10.3	6.0	7.3	3.3	2.6–4.1
S	(kg S/t grain)	2.1	2.2	2.0	2.4	0.9–3.2
Zn	(grams Zn/t grain)	53.0	49.5	47.0	Up to 72	13–24

Source: Data from Incitec Pivot Fertilisers' trial sites. Grain tests conducted by Nutrient Advantage laboratory.
*Sourced from Pacific Seeds Nutrition Booklets (2015), More Profit from Crop Nutrition (2015), Australian Soil Fertility Manual (2000), Incitec Pivot Fertilisers' data (unpublished).

removal from the sorghum trials has been much higher than the recognised published average of 3.3 kg of potassium per tonne of grain, at between 6 and 10 kg of potassium per tonne of grain.

The phosphorus results show instances of both higher and lower phosphorus removal than the recognised average of 3.4 kg of P per tonne of sorghum grain.

Start grain testing this season

Before embarking boots and all into the next fertiliser application season, it's a good idea to grain test at harvest. Grain testing is as simple as collecting 400 grams of harvested grain from the header, truck or silo and submitting it to the Nutrient Advantage laboratory for analysis.

You may wish to take samples from different summer crop species, or from numerous varieties or hybrids of the same species. Even comparing short and long fallow paddocks is likely to unearth some useful differences. Local data is always the best.

By combining this information with yield results you can calculate actual nutrient export data by crop species, paddock or hybrid/variety. This provides a very useful base for the next crop's fertiliser planning.

Consider running nutrient budgets based on previous soil tests, overlaying paddock history and fertiliser applications to estimate how much is left.

Soil testing is still critical, but wait for rain

Of course, a robust crop nutrition program should still include regular soil testing. This is best undertaken after some moisture recharges the soil profile. Consider soil sampling midway through the fallow to see where nutrient levels of individual paddocks are sitting in relation to critical values for the intended crop.

Full profile samples for nitrogen and sulphur can be taken again later in the fallow, when moisture has built up. This provides a more accurate picture of both the quantity of nitrogen and sulphur in the profile and its position. Soil testing paddocks with 50–60 per cent water filled pore space allows nitrogen budgets to be more reliant on fact, and less reliant on mineralisation assumptions. Application strategies can be fine-tuned from previous pre-plant applications.

Soil samples should be taken to the anticipated crop's rooting depth, with three to four segments such as 0–10 cm, 10–30 cm, 30–60 cm and 60–90 cm. This will show which nutrients are present and where they are in the soil profile. It can also reveal whether there are any subsoil constraints, such as salinity or chloride.

Problems with subsoil constraints can vary from time to time due to soil wetting and drying cycles. Damaging levels of chloride and salinity in the subsoil have been prevalent – and problematic – due to the dry weather.

Some species are more susceptible to salts than others, so it is worth knowing if or how much the intended crop may be affected. The value of soil testing in these situations is priceless.

For more information on grain nutrient testing or soil testing, call Bede on 0417 896 377 or email bede.omara@incitecpivot.com.au ■

Grain testing is a quick and reliable way to analyse the nutrient removal from this year's under-performing summer crops.

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Taking the local nutrient yardstick to national variety trials

TRIALS at Merredin in Western Australia's eastern grainbelt have demonstrated that fertiliser decisions largely do not affect the relative local performance of different wheat and barley varieties in this low rainfall environment.

Yield and grain quality rankings for wheat and barley varieties grown using local management practices – especially for crop nutrition – were shown to be reasonably consistent with those achieved in adjacent GRDC National Variety Trials (NVT).

The Merredin and Districts Farm Improvement Group (MADFIG) administered the *Yardstick* trials over three years from 2015, with investment from the GRDC and support from the Department of Primary Industries and Regional Development (DPIRD). The trials were established and managed by service providers Kalyx and Living Farm.

This project – identified as a priority by MADFIG and the Kwinana East GRDC Regional Cropping Solutions Network (RCSN) group – was designed to add value to NVT testing by using typical local grower nutrient management practices adjacent to the NVT site.

Independent variety trials

The GRDC NVT program provides access to independent results on the performance of recently released grain and field crop varieties. It is a national program of comparative crop variety

Seasonal variation had more impact on the performance of individual wheat varieties than nutrition strategies in trials at Merredin in WA's eastern grainbelt. (PHOTO: MADFIG)

The GRDC has invested in several *Yardstick* trials in WA, which are being locally managed and run in each of the state's five grain-receival port zones. (PHOTO: MADFIG)

testing with standardised trial management, data generation, collection and dissemination.

Merredin grower and MADFIG member Andrew Crook said the *Yardstick* trials were initiated after a series of dry seasons highlighted the importance of getting variety choice right and raised questions about whether varieties differed in their responses to fertiliser management.

"During this period, some local growers questioned whether NVT results were fully applicable to them given the standard amount of fertiliser used in the NVT trials was higher than rates commonly used by growers in the area," Andrew said.

"But results from three years of the *Yardstick* trials have shown that variety performance rankings, especially for wheat, are reasonably consistent with NVT variety rankings in the area.

"This should give local growers confidence that varieties that perform well within the NVT program should also perform well when grown under their own management systems."

Andrew said the trials also highlighted that seasonal variation had a greater impact on individual variety performance than nutrition strategies.

"This highlights the importance of understanding the key factors that will influence variety performance and how they will perform across seasons," he said.

How the *Yardstick* trials are done

The trials, on medium-to-heavy textured soils, evaluated 10 wheat varieties and five barley varieties in 2015, 12 wheat varieties and five barley varieties in 2016, and 14 wheat varieties and six barley varieties in 2017.

Four nutrition strategies were implemented across the wheat and barley trials to represent various district fertiliser strategies reflective of common seasonal or budgetary scenarios.

Three of the treatments remained the same for the three seasons and a 'play the season' strategy differed depending on rainfall.

Fertiliser strategies included lower rates of phosphorus and generally lower rates of nitrogen than those used in the adjacent NVT trials.

"The results indicate that some fertiliser is equal to, or better than none, for all varieties tested across the seasons," Andrew said. "Recognising favourable seasons and responding with appropriate management is the challenge, as there is a greater opportunity cost from not maximising profit potential in a favourable season.

"Equally, the trial results show the importance of being conservative in a dry season."

MADFIG acknowledge the vital role of Merredin-based DPIRD staff Vanessa Stewart and Jenni Clausen in the delivery of the trials and research outcomes. The support from Jenni was possible due to her involvement in the DPIRD and GRDC project 'Building crop protection and production agronomy research and development capacity in regional WA'.

The GRDC has recently produced a video and podcast about its national NVT program. To view the video, go to http://bit.ly/2zSO5My. To listen to the new GRDC podcast, go to http://bit.ly/2CT2FoC ■

Wild radish resistant to atrazine, super-sensitive to bromoxynil

By Peter Newman

Alexander Graham Bell famously said: "When one door closes another door opens, but we so often look so long and so regretfully upon the closed door, that we do not see the ones which open for us."

ATRAZINE resistant wild radish looks a lot like a door closing, but in many cases, it's also a door opening for bromoxynil.

Some new research by AHRI PhD student, Huan Lu, has shed some light on atrazine resistant wild radish and the results have some very practical applications for growers and agronomists.

The most common target site mutation that causes atrazine resistance in wild radish is the 264 mutation – the same mutation that gave us TT Canola. The only way to kill radish with this mutation is to sit the atrazine drum on top of them! They have very high resistance to atrazine and as it turns out they are super-sensitive to bromoxynil, requiring only about a third of the brom rate that it takes to kill susceptible wild radish. Wild radish with the 264 mutation is also resistant to metribuzin.

Huan Lu also discovered a new target site mutation, the 274 mutation that causes modest levels of resistance to atrazine, metribuzin and diuron but not bromoxynil.

If you are gazing regretfully at atrazine resistant wild radish perhaps spare a thought for the super sensitivity to bromoxynil that may have resulted.

Atrazine resistant radish is easy to kill with bromoxynil

This is big news, and you may have even seen it with your own eyes in the field. Huan Lu found that if you have highly resistant radish with the very common 264 mutation, it's super sensitive to bromoxynil. This phenomenon is also sometimes called negative cross-resistance. Wild radish with the 264 mutation has an LD50 for bromoxynil of only 15 grams per hectare compared to 49 grams per hectare for the susceptible (Table 1).

In other words, it's about three times as easy to kill with bromoxynil. Products such as Jaguar and Velocity that contain bromoxynil get a free kick with triazine resistant radish.

Wild radish with the less common 274 mutation was not resistant to bromoxynil.

How does it work?

Atrazine binds to the D1 protein by hydrogen bonds. When the 264 mutation is present, atrazine can't form these H-bonds and high-level resistance results. Bromoxynil is the complete opposite. When the 264 mutation is present, bromoxynil forms an extra H-bond to the D1 protein resulting in super-sensitivity to bromoxynil. The D1 protein is an integral part of the electron transfer in photosynthesis.

TABLE 1: LD50 of a susceptible wild radish population at two to three leaf compared to wild radish with either the 264-Gly or 274-Val mutation

Herbicide	LD50 (g/ha)		
	Susceptible	264 mutation	274 mutation
Atrazine	6	>4000	207
Metribuzin	15		57
Diuron	59		345
Bromoxynil	49	15	44

LD50 = lethal dose in gai per hectare to kill 50 per cent of the population.

The 274 mutation

This research discovered the first evidence of the 274 mutation in wild radish. This mutation causes modest levels of resistance to atrazine, metribuzin and diuron as can be seen in Table 1 and the dose-response curves in Figure 1.

In Australia, the triazines (eg. atrazine), the triazinones (eg. metribuzin), the ureas (eg. diuron) and the nitriles (eg. bromoxynil) are all group C herbicides. They all target photosynthesis, more specifically the electron transfer in PSII, but at slightly different binding sites – so we can't treat them all the same. There are seven known target site mutations that cause resistance to this group of herbicide.

Dose-response

The dose-response curves In Figure 1 illustrate the difference in resistance patterns between the different mutations. It's

Atrazine resistant wild radish may just be super sensitive to bromoxynil. (PHOTO: Danica Goggin)

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interesting to see how highly resistant the 264 population is to atrazine in chart (a), yet the opposite is true for bromoxynil in chart (d).

Metribuzin and the 264 mutation

You'll notice in the dose-response curves that Huan Lu didn't do a dose-response for metribuzin for the 264 population. Other research has confirmed that the common 264 mutation also causes metribuzin resistance, but not the very high-level resistance that we see with atrazine with this mutation. This may explain why some farmers and agronomists have seen that they still get some useful control from metribuzin on wild radish in lupins where they know they have atrazine resistant wild radish.

70 per cent market share – the back story

The northern wheatbelt of Western Australia represents Australia's highest level of adoption of glyphosate-tolerant canola with an approximate 70 per cent market share. Why? Triazine-resistant wild radish. This region is famous for the very long lupin-wheat rotation that some farmers have now operated for 40 years or so. This rotation is heavily reliant on simazine, and it's likely that this long period of simazine use resulted in the widespread evolution of triazine resistant wild radish in the region. The only way to profitably grow canola in this region for many grain growers, is to use the glyphosate-tolerant technology to enable successful wild radish control.

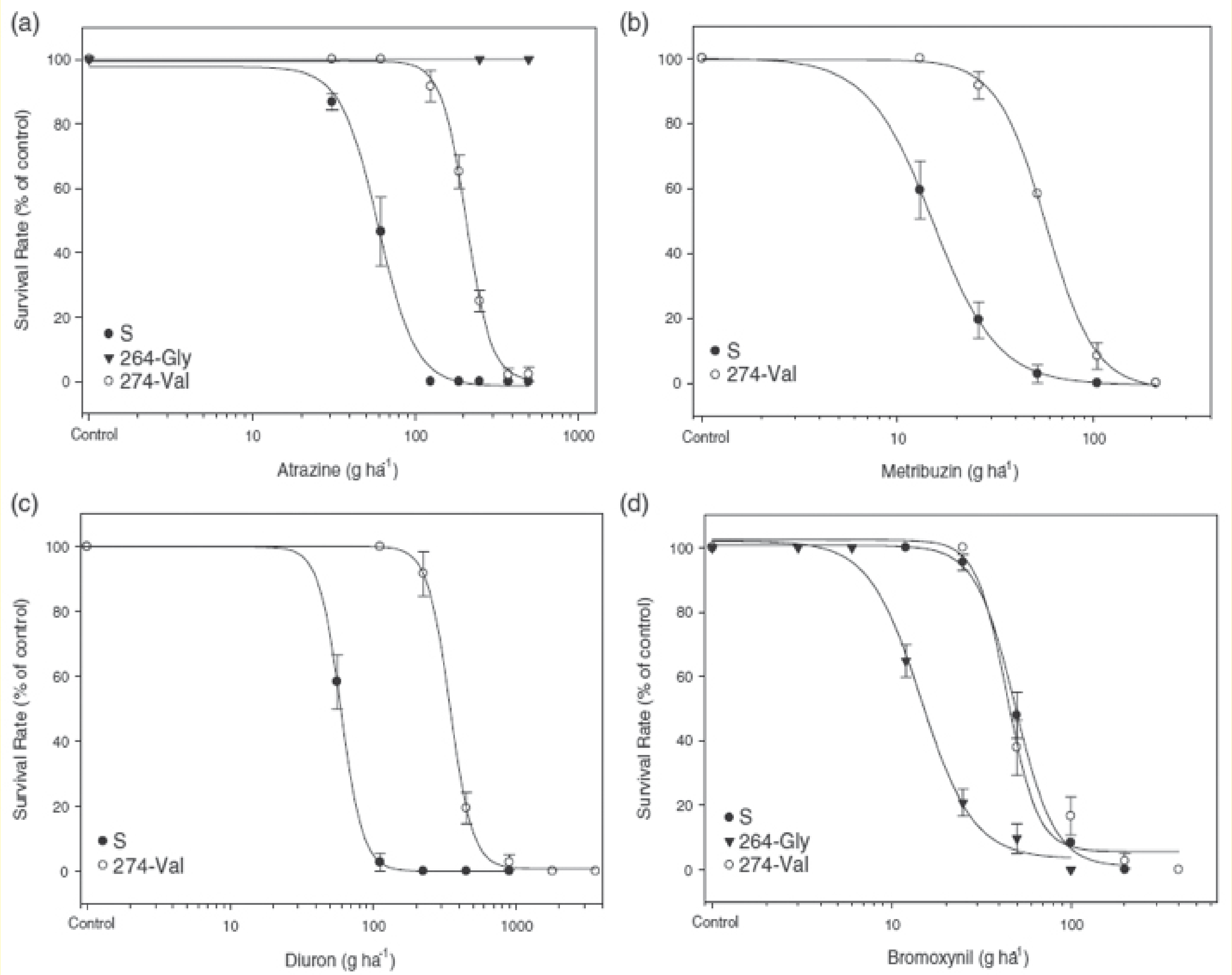
Breeding of TT canola

An interesting side note to this research is the story of how triazine tolerant (TT) canola was bred. A breeding program in Canada crossed a brassica weed with the 264 mutation with canola to produce TT canola. We know that this causes a 30 per cent 'fitness' penalty in canola and it is likely that the same will occur in wild radish. But given that wild radish is already exceptionally fit, we may not notice it in the field.

To sum up

At times it can be hard to see where all of this molecular biology research is headed, but this work can also give us great insight and help us understand what we are seeing in the field. This deep understanding of herbicide resistance mechanisms can have very practical applications and go a long way to helping us make good weed control decisions. ■

FIGURE 1: Dose-response curves based on survival rate for the S (●), 264=Gly (▼) and 274-Val (○) populations to selected PSII herbicides at 21 days after treatment



Data are means ± standard error (n=3). (a) atrazine, (b) metribuzin, (c) diuron and (d) bromoxynil.

Are grain crop burn-offs a cereal offence against the wine industry?

■ By Andrew Spence

AT A GLANCE…

A new smoke taint project in South Australia will study the impact of stubble burning by grain growers on wine grapes during harvest.

SEVERAL previous research projects have studied the impact on wine flavours of smoke from major bushfires and controlled public forest burns, but there is little analysis as to whether low intensity stubble fires have any lasting impact.

South Australian wine producing regions including the Barossa and Clare Valley, are adjacent to large swathes of grain-growing belts, which traditionally conduct any burn-offs during autumn.

Stubble burning is sometimes carried out to wipe out weeds, seeds and snails after harvest and before sowing.

But the timing sometimes coincides with wine vintage prompting the research by the University of Adelaide with the assistance of the Australian Wine Research Institute (AWRI).

AWRI Business Development Manager Dr Mark Krstic said the research would reveal more information about the ideal conditions for stubble burning to minimise any unintended risks of damage to grape and wine production.

Smoke taint research

"From our previous research on smoke taint, we know there are certain factors at play like smoke drift distance, type of smoke, time of day for burning, seasonal conditions, and wind speed," he said.

"We hope to be able to refine this through further research and give both the wine and grains industries enough information to make sound decisions when they are considering the needs of their own business, as well as their neighbours."

The Adelaide-based AWRI is a world leader in the field of wine smoke taint and was called in to help Tasmanian grape growers deal with the issue after major bushfires ravaged the state in January and February this year.

Trials over coming months will investigate the sensitivity of wine grapes to smoke from stubble burning.
(PHOTO: Barossa Grape & Wine Association)

South Australia produces about 50 per cent of Australia's wine and 75 per cent of the nation's premium wine each year, prompting the state government to provide $60,000 in funding to support the stubble burning research.

The state's Primary Industries and Regional Development Minister Tim Whetstone said although stubble burning was not as prevalent as it once was, it remained an important tool in the grain production cycle ahead of the planting of winter crops.

"The grains and wine sectors are two primary industry super powers in South Australia and it is important they are each able to co-exist without detriment to the other," said Tim.

The research will involve a series of field and winemaking trials in the coming months to discover the sensitivity of grapes to smoke from low intensity crop stubble burns. It will also seek to determine the exact point when smoke loses its potency to wine grapes. ■

Diverse crop rotation gives better long-term yield and protein

RESULTS from a trial in Western Australia's central grainbelt suggest the highest sustainable wheat crop yields and grain protein levels will be achieved from employing a diverse crop rotation – comprising wheat, a legume and canola – when compared with other rotations tested at the site.

The trial also produced the interesting result that retaining residue in a continuous cereal rotation significantly increased grain protein levels over the long term.

CSIRO researcher Phil Ward has worked on a long-term trial investigating the impacts of rotation diversity and residue handling on wheat yield and protein content.

"Factors influencing protein levels in wheat are an area of high importance and interest to grain growers," Phil says.

The trial has been conducted with GRDC investment on red loamy soil at Cunderdin (WA), where a long-term rotation trial was first established in 2007. The research has involved collaboration between the WA No-Tillage Farmers Association, The University of WA and CSIRO.

It has compared four rotations:

- Continuous wheat;
- Continuous cereal (wheat, wheat, barley);
- District practice (wheat, wheat, legume, and wheat, wheat, fallow); and,
- Diverse (wheat, legume, canola).

Growers and industry representatives being updated on a trial at Cunderdin investigating the impacts of rotation diversity and residue handling on wheat yield and protein content. (PHOTO: CSIRO)

What we found

Starting with the 2010 harvest, sub-plot treatments were established, comprising areas where residue was retained and spread behind the harvester, or windrowed and burned before sowing the next crop.

Nitrogen (N) was applied to each crop in response to seasonal conditions and expected N requirements. No extra N was applied to legumes or fallows.

Phil said differences between wheat yields in the various rotations were initially small for the first few years of the trial.

"But over the long-term, the diverse rotation – in which the frequency of cereal crops was 33 per cent – increased wheat yields by about 0.2 tonnes per hectare and wheat grain protein content by 0.9 to 1.6 per cent, when compared with continuous cereal or continuous wheat rotations," he said.

"Preliminary estimates suggest that these benefits are sustainable.

"While the causes of the yield and protein benefits are associated with including grain legumes in the rotation, there may be other benefits to do with soil nitrogen cycling that have not yet been quantified."

Phil said the district practice rotation – in which the frequency of cereal crops was 67 per cent – also resulted in higher grain yields (by about 0.4 tonnes per hectare) and higher grain protein levels (by 1.2 to 1.9 per cent) when compared with continuous cereal or continuous wheat rotations. But he said the sustainability of these benefits was yet to be determined.

"Without adequate replacement of soil nitrogen reserves in the district practice rotation, the high yields and protein benefits in this rotation might not last for much longer," he said.

Crop residue management

Phil said there was no consistent effect of residue management on crop yield.

"But retaining residue in the continuous cereal treatment significantly increased grain protein levels – from 11.2 per cent to 11.8 per cent from 2011 to 2017," Phil said.

"There was no significant effect of residue retention on average wheat grain protein in the diverse rotation.

"The retention of cereal stubble, with a generally low N content, was previously thought to tie up soil N, and was expected to lead to a decline in wheat grain protein.

"So the increase in grain protein with residue retention in the continuous cereal rotation was an interesting result."

This research was presented at the GRDC Grains Research Update in Perth in late February, 2019. ■

Strong demand continues amid production uncertainty...

■ By Peter McMeekin

THE Australian cattle market was in retreat in early March as the continued dry on the east coast forced cattle producers to sell down their herd. There is little or no pasture across most of New South Wales and southern Queensland, water supplies are drying up on many farms, and the cost of supplementary feeding is exceptionally high.

Peter McMeekin.

Traditional livestock selling centres in NSW and Queensland have all seen a substantial increase in yardings over the past few weeks. Some of these cattle will go direct to slaughter, but those that are suitable will make their way into the feedlot sector.

Meanwhile, the number of cattle on feed in Australia fell modestly in the final quarter of 2018, according to the latest Australian Lot Feeders Association (ALFA) and Meat and Livestock Australia (MLA) quarterly feedlot survey. The numbers revealed that 2018 closed with just over 1.11 million head in feedlots across the country – a fall of just 1.4 per cent from the record set in the previous quarter.

Over one million cattle in feedlots in Qld & NSW

The result means that 2018 is the first year there has been over one million head of cattle in the Australian feedlot system for the entire 12 months. The unrelenting drought in the eastern states has been a significant contributing factor with cattle being offloaded earlier than usual and in higher numbers.

The overwhelming sentiment is that feedlot numbers will remain strong in the first quarter of 2019. Export demand for Australian beef, particularly from China, remains strong, and the falling Aussie dollar has been assisting the cause. February shipments of Australian beef increased 11 per cent compared to the same month last year.

Queensland dominates the Australian feedlot sector with just

over 631,000 head – or 56.7 per cent of the total number of cattle on feed. NSW has around 326,000 head, or 29.5 per cent of the total. Collectively, these two eastern states make up 86.2 per cent of cattle on feed in the country.

It is this dominance and concentration of demand that has been the overriding driver of feed grain movements from west to east over the past 15 months. Poor grain production in northern NSW and Queensland for the previous two winters and three summers (including this summer) has led to a huge deficit.

If you add demand from the pig and poultry sectors, and from the specialised milling wheat and malting barley consumers, total wheat and barley movements into the ports of Brisbane, Newcastle and Port Kembla will most likely exceed 4 million tonnes (mt) by the end of the third quarter in 2019.

Relatively benign international scene

On the international front, yet another month has passed, and yet another USDA World Agricultural Supply and Demand Estimates report has been released. On the whole, the March report was quite benign, and futures markets reacted accordingly.

World wheat production for the 2018–19 marketing year is forecast to fall by 1.7 to 733 mt compared to the February estimate. Kazakhstan was the big mover with production down 1.0 mt, Argentina was down 0.3 mt, and Australia was up 0.3 to 17.3 mt.

Global wheat demand has decreased by 5.1 to 742 mt. The big mover here was India where demand was reduced by 3.0 mt, but their ending stocks were increased by 3.0 mt. The USDA have to balance the books somehow!

US ending stocks were up 1.2 mt which is more than 1.0 mt below last year's carry out, and the US wheat plantings are the lowest in more than 100 years.

World barley production was increased by a meagre 0.1 mt compared to the February forecast. But Australian production was increased by 1.0 to 8.3 mt and is now broadly in line with trade consensus in Australia.

Speaking of barley, there was a significant turnaround in market sentiment last week with old crop grower bids firming in both South Australia (up around $10) and Western Australia (up around $20). The renewed interest came from the big end of town, so it is most likely export driven.

Market rumours suggest that there may have been a delay to the imposition of Chinese import restrictions stemming from the current anti-dumping investigation. China has reportedly realised that they will need more Australian barley, particularly malting barley, before new crop Black Sea stocks become available in July.

Sources suggest that Beijing may have deferred a decision until May. Maybe just a rumour or maybe it has some substance. Only time – and the Chinese – will tell.

In the meantime, grain consumers in northern NSW and southern Queensland are getting increasingly concerned about the continued dry and its impact on winter crop production in their back yard. New crop stocks would generally be available when harvest ramps up early in the fourth quarter of the year.

But several big end users are believed to have taken some risk off the table by locking away some of their wheat and barley requirements through to the end of the year, and even into the first half of 2020. Current soil moisture levels across the entire region are well below average and the wet season is winding down, so the chances of a below average crop are quite high.

The carry-in stocks will be zero, and any production will be keenly sought so it would seem quite prudent to take some cover at this juncture. If it is the highest price that these consumers pay for their 2019–20 requirements, then happy days!

Article supplied March 12, 2019. Call your local Grain Brokers Australia representative on 1300 946 544 to discuss your grain marketing needs. ■

Grains industry to be a big winner in new Indonesia partnership

THE Australian grains industry will be a big winner following the formal signing on March 4 of the Indonesia-Australia Comprehensive Economic Partnership Agreement (IA-CEPA), according to AEGIC. CEO Richard Simonaitis said the Australian grains industry can now look forward to new levels of collaboration with Indonesia – Australia's single biggest wheat customer.

"I congratulate GrainGrowers Limited for working hard with the Australian Government to ensure grains are at the centre of the partnership," he said.

"As Indonesia continues to grow, the IA-CEPA will provide significant and lasting benefits to our two countries in terms of value for Australian growers; and food security and quality for Indonesia."

Richard said AEGIC looked forward to continuing to work with GrainGrowers and other industry partners on initiatives that will allow the grains and related industries in Australia and Indonesia to flourish even further.

Feedgrains and flour millers

Under the partnership, Australia will have access to the Indonesian feed grain market, with 500,000 tonnes tariff-free.

Richard said AEGIC had already been laying the groundwork to boost the value of Australian feed grains into Indonesia.

"Over the past 3 years we have been engaging feed grain nutrition experts to go into Indonesia and demonstrate to buyers the benefits of using Australian feed grains," he said.

"This work, and the provisions of the new partnership, will

INDONESIA AT A GLANCE…

- Indonesia is Australia's single biggest wheat customer.
- Each year Indonesia buys 4.2 mt of Australian wheat worth $1.2 billion (average).
- Indonesia's population will jump more than 30 million in little over a decade.
- Indonesians are becoming wealthier. Per capita GDP has grown from $780 in the early 2000s to more than $3800 in 2017.
- The Indonesian middle class has grown from 2 million in 2004 to a forecast 120 million in 2020 and is becoming highly urbanised.
- These changes are resulting in diets evolving to incorporate more wheat and meat products and less rice.

AEGIC's Richard Simonaitis used the recent GRDC Grains Research Updates in Perth to point out some of the benefits for the Australian grains industry of the new trade agreement with Indonesia.

give Australia a distinct advantage in capturing the rapidly growing Indonesian feed market. Indonesia's total feed imports are currently valued at more than $1 billion, and the market is growing fast as people increasingly eat more meat."

Richard said Indonesia had been a focus for AEGIC and the new partnership would strengthen this relationship.

"AEGIC is supporting Indonesian flour millers and processors through in-market education and technical support to help them get the most value out of Australian grains," he said.

"On the Australian end, we provide our grains industry participants with wheat quality training at our Sydney Pilot Mill to increase their understanding of the wheat quality requirements of Indonesian customers."

AEGIC is currently analysing future demand trends in the Indonesian market to help the Australian industry position itself to capture future opportunities. The second report in the series, focusing on the Indonesian noodle market, will be released soon. ■

Cover crops are unearthing the secrets to improved soil health

MULTI-SPECIES cover cropping is the most effective way to improve soil health, and has the potential to reverse damage caused by years of conventional, full tillage farming practices and boost the sustainability of broadacre dryland cropping in Australia. This conclusion is reached by 2017 Nuffield Scholar, Alex Nixon, whose global research on sustainable farm management practices points to the use of cover crops to greatly increase the health of soils.

Supported by the Grains Research and Development Corporation (GRDC), Alex used his Nuffield Scholarship to research the use of cover crops around the world, and develop a blueprint for the adoption of the emerging land management practice back home.

Alex runs an 8500 hectare cattle and cropping operation near Roma in southern Queensland. As the third generation of his family to farm the land – and with a young family of his own – a desire to leave his property in good condition for future generations motivated his research.

Healthy soils for future generations

"Successful, sustainable farming businesses depend on the health of their soils. Sown after completion of a cash crop, a multi-species cover crop can greatly enhance soil health by boosting biodiversity, ground cover and soil organic matter," Alex said.

Researching cover crop trials in the US, Alex revealed the benefits that cover cropping can have on the amount of organic matter present in soil.

"Field trials conducted in North Carolina and North Dakota revealed that several consecutive years of cover cropping had allowed organic matter to build up from 1.2 to 6.7 per cent," he said. "The residue from the cover crops slowly breaks down, providing food for microbes and boosting moisture retention, acting like a mulch."

Acknowledging that cover cropping in the Australian broadacre sector to date has been largely based on single species crops, Alex's final Nuffield report reveals that multi-species crops are more beneficial because they avoid the presence of a monoculture and boost microbial diversity and activity.

"Single-species cover crops do enhance ground cover, but by adding even one or two different species into a cover crop the microbial activity can be greatly enhanced, boosting the diversity of the soil ecosystem," he said.

Alex's research goes beyond the raw benefits of multi-species cover cropping, to explore the viability of the practice in an Australian context.

Barriers to adoption in the Australian context

"Despite the benefits, a number of barriers to adoption remain for Australian farmers," he said. "Upfront costs can be an issue. Cover crop seed is very expensive, as is the investment required for machinery or contract sowing.

"Visiting farms in the US and England, it was clear that the initial cover cropping season can result in some financial deficits.

"At Overbury Farms in England, long-term soil conservation had been prioritised over the short-term bank balance, and lower income was being supplemented by other revenue streams."

Alex's report recommends that Australian farmers looking to implement a multi-species cover crop regime start small, and consider the frequency and size of cover rotations based on the benefits they can produce.

Alex Nixon with sons, Archie (left) and Eddie (right) in their wheat crop at 'Jay-Dee' on the Western Darling Downs, Qld.

"While implementing diverse cover crops can pose initial economic issues, the long-term environmental and economic benefits outweigh any initial costs," he said.

"As soil health improves, input costs on fertiliser and chemicals decrease, while cash crop yields increase. A cover crop also opens up opportunities for alternative revenue streams through livestock grazing or agistment, before the cash crop goes back in.

"Through careful management, multi-species cover cropping is a viable option for Australian broadacre farmers seeking to improve soil health and preserve the landscape for generations to come," Alex says.

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Final Report: https://nuffieldinternational.org/live/Report/UK/2017/alex-nixon

Final Video Link: https://www.youtube.com/watch?v=eFh6gZ0uVvA&index=6&list=PLWdEyVDhYCcJfyWuxFQd0R8qX-E8FOcWh ■

One tiny step for a nematode, one big step for agriculture in space

■ By Sharon Durham, Agricultural Research Service – USDA

AN exciting collaboration between the USDA's Agricultural Research Service and Florida-based company Pheronym, will send nematodes into space to the International Space Station (ISS). The mission represents a look into the future where food crops will be grown in space.

The goal is to develop environmentally friendly methods for space travel that are not harmful to humans. This will be the first biological control experiment in space. The nematode's send-off, funded by the ISS US National Laboratory, hopes to launch to the orbiting platform as early as this year.

ARS research entomologist, David Shapiro-Ilan at the Fruit and Tree Nut Research Station in Byron, Georgia, is co-project director of an experiment that will be conducted on the ISS. The experiment will test the movement and infection behaviour of beneficial nematodes (also called entomopathogenic nematodes or EPNs) that control a wide array of insect pests in agriculture.

The EPNs are environmentally friendly alternatives to broad spectrum chemical insecticides and are also safe to humans and other non-target organisms. One fascinating aspect of the EPN biology is that the nematodes kill their insect pest hosts with the aid of symbiotic bacteria that are carried in the nematode gut.

For more than 20 years, David has studied EPNs from a practical standpoint such as improving their application as biological control agents for sustainable pest management. David also conducts related research on basic aspects of EPN behaviour, particularly movement and foraging behaviour.

Starship Nematode!

"The mission to space will offer a novel perspective and provide new insights into nematode behaviour," David says. "The unique microgravity environment will allow us to explore fundamental mechanisms in parasitism and pathogenesis."

The mission to space will offer a novel perspective and provide new insights into beneficial nematode behaviour.

The questions to be addressed regarding the effects of microgravity include:

- The ability of EPNs to navigate through soil, infect insects and reproduce, and will the nematodes' symbiotic bacteria function normally; and,
- They will also ascertain if the impact on insect host physiology is the same compared with what is observed on earth.

To address these questions, sealed soil columns containing nematodes and a model target pest (waxworms, *Galleria mellonella*) will be sent into space for 30 days.

David was a partner in designing the experiments that will be conducted on the International Space Station and he will play a key role in assessing results. Results will then be assessed once the nematodes return to earth. Control experiments with the same design will be conducted concurrently on earth for the same duration.

The nematode space mission project director, Fatma Kaplan, is the CEO of the company, Pheronym, an established cooperative research partner with USDA–ARS. Pheronym develops and produces nematode pheromones that can be used to direct EPN behaviour (such as dispersal); the goal is to use the pheromones to enhance biocontrol efficacy.

David and Fatma (and other partners) are funded by UDSA's National Institute of Food and Agriculture (NIFA) to explore production and application of nematode pheromones, and from NIFA's Agriculture and Food Research Initiative to investigate basic mechanisms in nematode movement and infection behaviour.

The ability of nematodes to produce and respond to pheromones under microgravity will also be explored in the space station experiments.

"This project of sending worms into space – which is being funded by the International Space Station US National Laboratory – is a natural off-shoot of the cooperative research between USDA-ARS and Pheronym," said David. ■

Can we refine winter crop planting dates further?

By Matt Gardner[1], Jules Dixon[2], Greg Giblett[3], Sam Simons[3] and Stephen Towells[1]

AT A GLANCE…

- Of all the agronomic 'levers' available to growers planting date still offers one of the greatest abilities to increase yield potential.
- There are drastic changes in frost risk with only small changes in elevation (20–50 m), which presents significant opportunity to push planting dates forward without necessarily increasing frost risk.
- Lower points in the landscape/paddock have more frost events with greater duration compared to higher elevations. Therefore there is slower accumulation of growing degree days at these lower points in the landscape, consequently slowing the development of the crop.
- There is little variation in maximum temperature across elevations. Therefore in lower parts of the landscape, where the frost risk persists longer into the season, the heat stress will start at the same time as higher elevations. This narrows the window for optimum conditions for flowering crops.

MAJOR management 'levers' that can be manipulated to achieve yield potentials include planting date, planting configuration (row spacing and seeding rate), variety choice, disease and weed control, nitrogen, phosphorus and other nutrition. Of these levers planting date can have the greatest impact achieving yield potential and is one of the few management tools that can be changed with negligible additional costs to the grower.

The degree that planting date will determine grain yield potential will be greatest in dry and hot springs and least in wet and mild springs.

Planting date determines when the plant will reach anthesis. Pushing sowing dates earlier increases yield potential through increased biomass accumulation and by extending the length of grain filling period under cooler spring temperatures. But earlier planting dates also increase the risk of incurring a frost during flowering.

Sowing later to minimise frost risk then pushes crops to grain fill under hotter spring conditions leading to lower yield potentials. Key questions include:

- Are we losing yield with current grower (traditional) sowing dates? and,
- What other tools are available to manage our sowing dates as early as possible without taking on board unacceptable frost risk?

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

Currently 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. The problem for growers and agronomists is that typically the local weather stations are located some distance from paddocks or farms which then requires a degree of interpolation (estimation).

Models are also based on these weather stations as well, which means growers can only use results as a guide. In relatively flat areas like Walgett in northern NSW, the individual farm variation from the weather station may be very small. For other locations like the Liverpool Plains, where there is a large variation in elevations, there is likely to be large differences across farms in their temperature regime as compared to the Gunnedah or Quirindi weather stations.

Our research aims to reduce some of the interpolation required by growers and agronomists by looking at the impact that elevation has on frost risk and subsequently planting dates across different elevations.

But the project hasn't taken into account other factors that will influence frost risk or cold air drainage such as aspect, drainage, tree lines and the point in the landscape.

The data produced from this project could be used in models to enable them to better predict frost risk and planting dates across the landscape rather than localised near a weather station.

What has been done?

In 2014, 2015 and 2016 two paddocks containing significant elevation differences (20–45 metres) were selected, one near Gurley and one on the Liverpool Plains. In each paddock a site was selected at the top of the slope and a site was selected at the bottom of the slope. Tiny Tags were installed along with rain gauges at both sites in each paddock to record temperature (every 15 minutes) and rainfall.

Six wheat varieties including LPB Dart, LPB Spitfire, Suntop, LPB Lancer, EGA Gregory and EGA Eaglehawk were planted on three planting dates (approximately last week of April, mid May and early June for all trials) at both sites.

Regular phenology measurements were taken to ascertain development difference both between varieties but also between top and bottom slopes.

A summary of the site planting dates and elevation differences is given in Table 1.

TABLE 1: Details of planting dates and elevation differences at each site between 2014 and 2016

	Premer 2014	Gurley 2014	Spring Ridge 2015	Gurley 2015	Premer 2016	Gurley 2016
Planting dates	30th April 20th May 13th June	26th April 16th May 11th June	30th April 19th May 11th June	26th April 15th May 8th June	29th April 18th May 13th June	30th April 17th May 10th June
Elevation difference	401–377 (24 m)	271–302 (32 m)	354–309 (45 m)	306–263 (43 m)	384–404 (20 m)	309–274 (35 m)

Planting date is one of our most effective management levers.

What we found

Estimations of starting plant available water (PAW) indicated that although profiles were similar between top and bottom slope at all sites the bottom slope generally had slightly higher starting PAW between two and 20 mm more than the top of the slope. In 2015 and 2016 the starting PAW, was approximately 70 to 90 per cent full at the Liverpool Plains and Gurley sites, but in 2014 starting PAW was closer to 50 per cent full at both locations (Table 2). Similar to starting PAW the measured available soil N values were generally slightly higher at the bottom slope sites compared to the top of slope sites containing an additional 2–17 kg N per hectare available at the start of the season (Table 2).

FIGURE 1: A visual representation of how different maturity was between top and bottom slope at Spring Ridge in 2015

TABLE 3: Average days to flower for LPB Dart, LPB Spitfire, Suntop, EGA Gregory, LPB Lancer and EGA Eaglehawk sown across three planting dates at the top and bottom slope sites at the Liverpool Plains and Gurley

Site	Slope	Late April	Mid May	Early June
Premer 2014	Top	131	126	116
	Bottom	147	138	127
Gurley 2014	Top	94	114	102
	Bottom	106	123	108
Spring Ridge 2015	Top	130	124	117
	Bottom	144	133	124
Gurley 2015	Top	118	109	99
	Bottom	126	116	106
Premer 2016	Top	141	132	121
	Bottom	149	135	126
Gurley 2016	Top	123	119	110
	Bottom	130	126	116

The elevation differences at both sites resulted in significant variation in temperature over the season. Average minimum temperatures across all three years were 2.4 and 2.9°C lower at the bottom slope compared to the top slope at Liverpool Plains and Gurley, respectively, whereas average maximum temperatures were similar for both top and bottom slopes (Table 2).

The differences in average minimum temperatures was exemplified by the differences in frost events (<0°C) with bottom slope at the Liverpool Plains and Gurley. At Spring Ridge and Premer in 2014, 2015 and 2016 the bottom slope experienced an additional 27, 35 and 28 frost events, respectively, compared to the top slope. At Gurley in 2014, 2015 and 2016 the bottom slope experienced an additional 31, 29 and 36 frost events, respectively, compared to the top slope (Table 2). There were not only more frosts at the bottom slope sites but frosts had a greater duration.

On average across years the time that temperatures were at or below 0°C at the top slope was only 36 and 7 per cent of that measured for the bottom slope sites on the Liverpool Plains and at Gurley, respectively (Table 2). Length of the frost event can be a major determining factor of damage.

TABLE 2: Soil and temperature differences between top and bottom slope at all sites from 2014 to 2016

Site	Slope	Starting PAW	Soil N (0–1.2 m)	Average min	Average max	Frost events (<0°C)	Cum. hours (<0°C)	Season GDD
Premer 2014	Top	139	110	5.1	24.6	31	97	1963
	Bottom	158	122	2.5	24.8	58	226	1655
Gurley 2014	Top	90	154	7.1	30.7	7	21	2230
	Bottom	108	145	4.4	30.3	38	184	2038
Spring Ridge 2015	Top	185	175	5.4	22.6	16	32	1998
	Bottom	200	192	2.6	23.1	51	243	1752
Gurley 2015	Top	144	104	6.4	25.2	7	17	2186
	Bottom	146	118	2.9	24.8	36	176	2008
Premer 2016	Top	225	125	4.9	22.8	31	132	1869
	Bottom	230	128	3.1	22.9	59	253	1655
Gurley 2016	Top	115	138	6.8	27.9	1	0.45	2138
	Bottom	126	142	4.3	28.0	37	143	1967

This project has highlighted the very large yield and financial benefits possible from early wheat planting at higher, and less frost-prone, parts of the paddock.

On average across the three years the length of frost events at the top slope sites were 3.3 and 2.5 hours for the Liverpool Plains and Gurley, respectively. This is compared to the bottom slope sites on the Liverpool Plains and Gurley where frost events typically lasted for 4.3 and 4.6 hours, respectively.

Growing Degree Days and crop maturity

Lower average minimum temperatures and greater number of frost events both contributed to the slower accumulation of thermal time throughout the season at the bottom slope compared to the top slope.

At both locations the difference in accumulated thermal time (Growing Degree Days – GDD) was in excess of 150 GDD higher at the top slope sites (Table 2).

The variation of minimum temperature and ultimately GDD had significant impact on crop maturity. Despite being planted on the same day at the top and bottom slope sites, the varieties did not reach 50 per cent flowering on the same day. An example of how visual this difference was is shown in Figure 1.

The bottom slope sites were on average across the six varieties 13, 9 and 7 days longer than the top slope to reach flowering on the late April, mid May and early June planting dates, respectively for the Liverpool Plains (Table 3). Similarly, for Gurley the differences in time taken to reach flowering were 9, 8 and 6 days longer at the bottom slope sites than the top slope for the late April, mid May and early June planting dates, respectively (Table 3).

The Liverpool Plains trials were on average 17 days later to reach flowering compared to Gurley trials across the three years.

The Liverpool Plains and Gurley had hot and dry springs in 2014 and 2015 and in these seasons the real benefit of early planting was realised. For example on the Liverpool Plains at the top slope site delaying planting from late April to early June resulted in a 2.24 and 1.04 tonnes per hectare loss in grain yield when averaged across six varieties in 2014 and 2015, respectively (Table 4). Assuming a wheat price of $250 per tonne this is equivalent to $560 and $260 per hectare increase in net returns, respectively.

Despite very favourable spring conditions on the Liverpool Plains in 2016 there was still a 1.34 tonnes per hectare yield penalty for delaying planting dates from late April to early June at the top of the slope. Again assuming a wheat price of $250 per tonne the late April planting date allowed an additional $425 per hectare and $1155 per hectare net return to be realised, compared to the mid May and early June planting dates, respectively at the top of the slope over three years (Table 4).

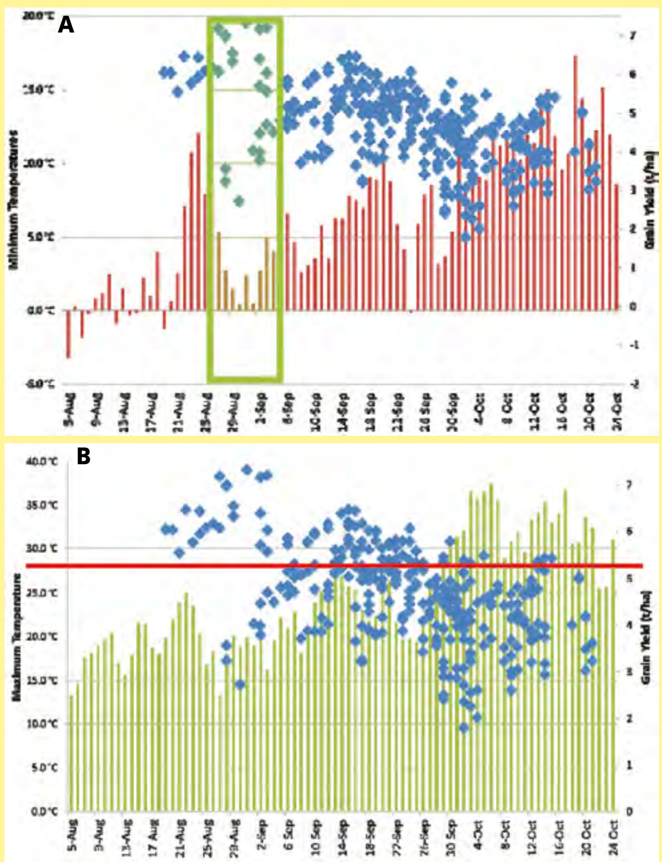
Frost damage did occur at the bottom slope sites on the Liverpool Plains in all three years, particularly in LPB Dart and LPB

TABLE 4: Average grain yield for LPB Dart, LPB Spitfire, Suntop, EGA Gregory, LPB Lancer and EGA Eaglehawk sown across three planting dates at the top and bottom slope sites at the Liverpool Plains and Gurley and restrospective optimum flowering times for highest yield potential

Site	Slope	Late April	Mid May	Early June	Optimum flowering window
Premer 2014	Top	5.24	4.28	3.00	1st Sep–12th Sep
	Bottom	4.68	4.42	3.16	10th Sep–20th Sep
Gurley 2014	Top	—	1.56	1.19	18th Aug–3th Sep
	Bottom	1.26	1.60	1.42	28th Aug–10th Sep
Spring Ridge 2015	Top	5.37	4.90	4.33	25th Aug–5th Sep
	Bottom	4.53	5.18	4.60	16th Sep–25th Sep
Gurley 2015	Top	5.25	4.56	3.37	11th Aug–24th Aug
	Bottom	4.62	5.01	3.62	24th Aug–9th Sep
Premer 2016	Top	7.52	7.25	6.18	8th Sep–28th Sep
	Bottom	7.01	7.34	6.05	20th Sep–10th Oct
Gurley 2016	Top	6.32	6.41	6.57	6th Sep–30th Sep
	Bottom	5.98	6.56	6.51	15th Sep–30th Sep

Spitfire. For example LPB Dart in 2015 at Spring Ridge yielded 6.17 and 1.23 tonnes per hectare at the top and bottom slope sites, respectively. The frost damage at the bottom of the slope reduced average grain yield of the six varieties by 1.91 tonnes per hectare across the three years (Table 4). Minimal frost damage incurred on the two later planting dates as grain yields were similar between the top and bottom slope sites for the Liverpool Plains and Gurley in all three years.

FIGURE 2: A) Minimum temperatures (red bars) and grain yield x anthesis date (blue diamonds) for individual plots for top slope at Spring Ridge in 2015. Green box indicates the retrospective optimum flowering date at site. B) Maximum temperatures (green bars) and grain yield x anthesis date (blue diamonds) for individual plots for top slope at Spring Ridge in 2015. Red line indicates 28°C.



Unlike the Liverpool Plains in 2016, there was no yield penalty in delaying planting date from late April until early June at Gurley (Table 4). This is compared to 2015, which had a hot dry spring, where the same delay in planting date resulted in a 1.88 tonnes per hectare reduction in grain yield (Table 4).

What was the optimum flowering time?

The optimum flowering window was retrospectively established by plotting grain yield against flowering date to see what period achieved the maximum grain yields.

At Gurley in 2014 and 2015 the optimum flowering windows were generally 12–14 days from mid to late August for the top of slope site, whereas in 2016 the optimum flowering window was much wider (24 days) and began in early September (Table 4).

The length of the optimum flowering window for the bottom slope site at Gurley was similar to the top slope for the respective years, but it generally started 9–13 days later.

The delayed optimum flowering window for the bottom slope sites was also observed on the Liverpool Plains where it started 10–22 days later than the top of the slope (Table 4).

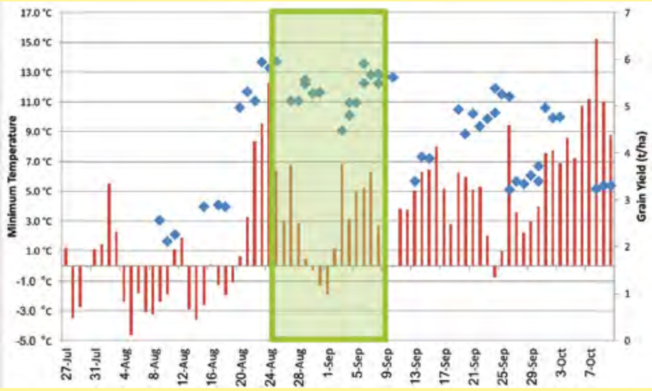
Optimum flowering windows on the Liverpool Plains for the top slope sites generally started around the beginning of September while the optimum flowering window for the bottom of the slope generally started around mid-September (Table 4).

The 2015 season data for Spring Ridge is presented in Figure 2 to demonstrate how the optimum flowering window was determined and how fine the line is between frost damage, particularly at the bottom of the slope.

Further, the 2015 season clearly illustrates the hot dry conditions during grain fill. At the Spring Ridge top slope the highest grain yields were achieved when varieties flowered between August 25 and September 5.

There were no frost events that occurred during this same period, with the last frost event occurring on August 18 (Figure 2A). In the first week of October there were five consecutive days where maximum temperature exceeded 35°C (Figure 2B). Maximum temperatures exceeded 28°C everyday between September 28 and October 22.

FIGURE 3: Minimum temperatures (red bars) and grain yield x anthesis date (blue diamonds) for individual plots for bottom slope at Gurley in 2015. Green box indicates the retrospective optimum flowering date at the site.



Retrospectively, the highest yields were achieved when varieties flowered between September 15 and 25 for the bottom slope site at Spring Ridge. Unlike the top slope, the last frost at the bottom slope site occurred on September 30. Frost events in the last week of August appear to have had a significant impact on grain yields of varieties that have flowered prior to September 10. The extent of this frost damage was evident in LPB Dart in the field, where in excess of 90 per cent of primary tillers had frost damage.

Maximum yields for top slope at Gurley were achieved when flowering dates occurred between August 11 and 23. There was one small frost event that occurred during this period. But there were only two frost events that occurred near flowering that were lower than -0.5°C (July 28 and August 5). After October 28 there were 13 consecutive days where maximum temperatures exceeded 28°C and four days where temperatures exceeded 35°C.

For the bottom slope the retrospective optimum flowering dates were between August 24 and September 9. Interestingly, four frost events occurred in this same period (Figure 3). Unlike the top slope there were 17 frosts that occurred between July 27 and August 9 that had minimums below -0.5°C.

To sum up

The data collected in these trials demonstrates why there should be significant motivation to plant paddocks as early as possible to maximise optimal grain filling conditions while avoiding risk of frost damage. On the Liverpool Plains assuming a wheat price of $250 per tonne the late April planting date has created an additional $425 per hectare and $1155 per hectare net return compared to the mid May and early June planting dates, respectively at the top of the slope over three years.

Even in 2016 when optimal spring conditions prevailed there was still a 1.34 tonnes per hectare yield penalty for delaying planting dates from late April to early June at the top of the slope on the Liverpool Plains.

There are few other management tools available to growers that can manipulate net returns to this extent. Admittedly, the 2014 and 2015 seasons exacerbated the impact of planting date due to well below average September rain that was followed by extremely hot weather in early October. Both these factors would have contributed to restricting the grain filling period for long season varieties or later planting dates.

The two locations demonstrate that frost risk can vary greatly within the landscape, particularly with elevation differences. This represents an opportunity for growers to be able to plant earlier in certain parts of the landscape without necessarily increasing their exposure to frost risk.

The top slope sites only had 30 and 20 per cent of the frost events that occurred at the bottom slope on the Liverpool Plains and Gurley, respectively. Not only are there less frost events but the frost severity is also greatly reduced. Top slope sites had 45 per cent higher average minimum temperatures and only accumulated 11 per cent of the time spent <0°C compared to the bottom of the slope when averaged across all sites and locations.

The impact of this drastic difference in frost risk is evident on the April planting date in 2015 at both Spring Ridge and Gurley with the two quicker varieties, LPB Dart and LPB Spitfire. For the bottom slope LPB Dart was 60 and 81 per cent lower yielding compared to the top slope sown in late April at Gurley and Spring Ridge, respectively.

Also on the late April plant LPB Spitfire was 61 and 43 per cent lower yielding at the bottom of the slope compared to the top slope site at Spring Ridge and Gurley, respectively. It was interesting to note that at both Spring Ridge and Gurley, Suntop flowered approximately five days later than LPB Spitfire yet grain yields were 2.4 and 2.7 tonnes per hectare higher, respectively. This suggests that four to five days difference in flowering date could be a difference of 50 per cent in yield losses to frost damage. Varietal difference in tolerance to frost damage may in part also explain some of the differences between LPB Spitfire and Suntop.

Despite the top slope sites at either Gurley or the Liverpool Plains experiencing frost events during all three seasons there was not one instance where significant frost damage was recorded, even in the quickest variety, LPB Dart. Therefore, even earlier planting dates were required at the top slope sites to incur yield penalties from frost.

The significant differences in minimum temperatures between top and bottom slope has also had an interesting impact on crop maturity. The greater number of frost events and severity has in turn slowed down the accumulation of GDD throughout the season, to the extent that the bottom slope at both locations accumulated over 150 GDD less than the top slope. As a direct result of this the crop maturity was delayed. The maturity delay is greatest on the early planting with and average delay of 11 days for varieties to reach flowering.

This is interesting as the delay in maturity is actually helping to negate some of the frost risk at the bottom of the slope. In a majority of cases the optimum flowering window at both Gurley and Liverpool Plains was 14 days later at the bottom of the slope compared to the top slope.

Alarmingly, there were a number of instances where frost events had occurred during the optimum flowering window at the bottom slope sites for both locations. Although these frost events appear to have had little impact on grain yield in these years it does highlight the higher risk of incurring frost damage in these lower parts of the landscape.

Furthermore, it highlights that frost events at lower elevations are persisting longer into the season, yet the onset of potential heat stress is no different to higher elevations, thus reducing the length of the optimum flowering window.

[1]AMPS Research. [2]Formerly AMPS Research. [3]Agromax Consulting

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

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Barley growers advised to get winter crop ready

BARLEY growers are being advised to get winter crop ready and reduce costly disease issues, like barley stem rust, by taking action now to control weeds and crop volunteers. The advice comes from Queensland Department of Agriculture and Fisheries (DAF) pathologist Lisle Snyman. An outbreak of barley stem rest occurred late last season in southern Queensland.

DAF pathologist Lisle Snyman.

Lisle says the dry conditions in 2018 in the eastern states resulted in low overall disease levels, so it was surprising to see such an outbreak on the Darling Downs in October.

"Most crops in the region had been planted in June, which was not particularly late," Lisle said. "But a dry season meant crops generally hadn't received early fungicide applications.

"The development of stem rust is favoured by warmer temperatures late in the season and typically barley crops are drying down and not vulnerable at this time.

"But when storms in October 2018 delivered significant rainfall across much of the central and eastern Darling Downs, many barley crops developed late tillers, and this increased the vulnerability of crops to stem rust."

Barley infected by three types of stem rust

Barley can be infected by three types of stem rust:

- Wheat stem rust;
- Rye stem rust; and,
- A form that is regarded as a hybrid between the two known as 'scabrum' rust. This pathogen is mainly found on the native grass *Elymus scaber* (common wheat grass) where it is thought to have developed.

Lisle said extensive testing of crop samples from 2018 had identified the disease as scabrum rust, which is not a new pathogen and importantly does not infect wheat.

"It was important to understand what form of stem rust was being seen in paddocks, to determine the level of risk to crops. Screening by the Australian Cereal Rust Control Program at the University of Sydney confirmed scabrum rust, which was reassuring as this pathogen poses no threat to wheat production."

Strategies to minimise the risk of disease

"While we don't fully understand the stem rust outbreak on the Darling Downs in 2018, we do know there are strategies we can use now to minimise the risks for 2019," Lisle said.

Rust is considered a major disease of cereals worldwide. The rust pathogen has the ability to adapt to a range of environments. Spores are windborne and easily spread – as little as one infected leaf per 12 hectares of regrowth surviving through summer and early autumn can cause a rust epidemic in the following cereal crop.

Critically, Lisle said the rust pathogen was a biotroph, meaning it required a living host for survival.

"This pathogen can not survive in stubble, so by controlling the 'green bridge', or crop volunteers, and native grasses (such as *Elymus scaber*), grain growers can significantly reduce the potential risk of rust outbreaks in winter crops," she said.

"It is important growers take action where appropriate now to control the green bridge, because most barley varieties are vulnerable to stem rust infection and will host wheat, rye and scabrum rusts."

Lisle presented her findings on the Darling Downs stem rust outbreak in late 2018 as part of her presentation at the GRDC Grains Research Update in Goondiwindi on March 5. ■

An outbreak of barley stem rest occurred late in the 2018 season in the Brigalow, Chinchilla, Dalby, Brookstead and Jandowae regions of southern Queensland. This was surprising given the dry seasonal conditions. (PHOTO: DAF)

Fighting fungicide resistance in a key barley disease

THERE are management strategies to help grain growers minimise the development of fungicide resistance in spot form of net blotch (SFNB) – one of Australia's most damaging barley diseases.

Dr Fran Lopez-Ruiz from the Centre for Crop and Disease Management (CCDM) says the control of fungal diseases in broadacre crops is often very reliant on the use of fungicides, but their continuous application has led to the development of resistance in fungal pathogens which in turn increases management costs and impacts on farm profitability.

Fran said fungicide resistance to some Group 3 DeMethylation Inhibitors (DMI) fungicides in SFNB, a disease caused by the pathogen *Pyrenophora teres f. maculata*, was present in southern grain growing regions of Western Australia.

CCDM Fungicide Resistance Management and Disease Impact Theme leader Fran Lopez-Ruiz (left), working in the lab with fellow CCDM researcher Wesley Mair. (PHOTO: CCDM)

He said sampling work detected SFNB strains moderately resistant to fungicide in the Esperance region from 2016 onwards, and highly resistant strains in the Great Southern and Esperance regions from 2017 onwards.

Current control measures for SFNB include the application of effective fungicides as well as on-farm practices that reduce disease establishment, reproduction, dispersal and survival. The use of varieties that contain genetic resistance to the disease is also effective.

"But due to the current lack of highly resistant cultivars, SFNB is controlled mainly using fungicides," Fran said. "Growers need to take a cautious approach with controlling SFNB and implement adequate integrated disease management strategies to minimise the ongoing selection of SFNB resistant populations.

"Being a stubble-borne disease, rotating crops or managing stubble are paramount for reducing disease carry-over, and selecting varieties that have disease resistance will reduce the severity of SFNB during the growing season.

"But these measures will not be very effective unless growers choose fungicides carefully.

"Any spray program that is heavily dependent on Group 3 fungicides will increase the risk of resistant populations developing," Fran warns.

Seed dressings and fungicide mixtures

"I encourage growers to use seed dressings, as well as in-furrow and foliar products containing fungicide mixtures from different chemical groups (Groups 3, 7 and 11), and to remove tebuconazole from control programs in areas where resistance has been found.

"This will help to limit the spread of resistance in SFNB and its emergence in other barley growing regions of Australia."

In addition to using cultivars with good disease resistance levels, other cultural practices that growers can use to limit the development of resistance in SFNB include using disease-free seed; employing stubble management strategies to reduce the disease load; rotating crops; grazing with livestock; and, maintaining good farm hygiene.

Recommended chemical management strategies

- Only spray if necessary – limit applications;
- Choose fungicide mixtures with different modes of action (if available);
- Never apply the same Group 3 fungicide consecutively;
- Avoid consecutive use of fungicides with the same mode of action from Groups 7, or Succinate dehydrogenase inhibitor (SDHI), and Group 11, or quinone outside inhibitors (QoI);
- Incorporate the use of seed dressings (Group 7), in-furrow (Group 11) and foliar products containing fungicide mixtures from different chemical groups (such as Groups 3 (DMI), 7 (SDHI) and 11 (QoI) – in combination with limited use of propiconazole and no stand-alone tebuconazole use;
- Ideally use DMI-based mixtures (eg. Prosaro containing prothioconazole and tebuconazole) only once, followed by mixtures with other actives (preferably from Groups 7 or 11);
- If resistance is present or suspected, avoid or minimise use of that mode of action, as continuing its use will only further select for resistance; and,
- Do not exceed label rates.

CCDM research into SFNB is supported by GRDC investment, with this latest work also involving the Department of Primary Industries and Regional Development (DPIRD) and the Foundation for Arable Research in Australia.

More information about SFNB management is available in the GRDC Barley GrowNotes at *https://grdc.com.au/grownotes* ■

Are our weed seed ecology studies done correctly?

■ **By Bhagirath S. Chauhan, Associate Professor, QAAFI, University of Queensland, Gatton**

AT A GLANCE

- Studies on weed seed germination ecology have increased in Australia – this is a good thing. But we need to understand some basics to correctly conduct these studies.
- This article provides answers to some basic questions related to seed germination ecology.

WEEDS are among the most important biological constraints to crop production. They are also a problem on roadsides, railway lines and in the natural environment. Weeds reduce the productivity of a number of primary industries. For example, in Australia weeds cost grain growers alone more than $3 billion annually.

Herbicides are used widely to manage weeds but there are concerns around environmental pollution, the scarcity of products with new modes of action and the evolution of herbicide resistance in weeds. Globally, about 500 unique cases of herbicide-resistant weeds have been recorded and Australia is in second place – after the US – on this unenviable list.

There is a need to develop integrated weed management (IWM) strategies to reduce reliance on herbicides. But to develop IWM programs, a basic understanding of weed biology is required, and seed germination ecology is an important component of weed biology.

Mistakes are being made

In my view, mistakes are being made in seed ecology studies. This article sets out to answer some basic questions related to weed seed germination ecology studies. Some ideas are taken from Baskin *et al* (*Seed Science Research*, 2006, 16:165–168) and

Bhagirath Chauhan.

I strongly suggest that all researchers working in this area should read this article.

The following questions and answers outline what I believe we need to know to ensure weed ecology studies are done correctly.

Question 1: *How should I collect weed seeds?*

Answer 1: Collect only mature seeds as green seeds may not be fully viable. After drying, green seeds look similar to mature seeds but in reality, they may not be viable. The best way to collect mature seeds is by shaking the plant. Pulling seeds from a panicle/inflorescence may result in non-viable seeds in the sample. These seeds are okay if you need to grow seedlings. For example, you can increase seed rate, even if viable seeds are only 10 per cent. But if the aim is to evaluate percent germination, the used seeds should be 100 per cent viable.

Q2: *When should I do a germination test for seed dormancy?*

A2: Initial germination tests (ie. the dormancy level in fresh seeds) should be conducted very soon after seed collection. Seeds may be dried for two to three days in natural conditions (avoid contact with water) and then the test should be conducted. Some researchers conduct germination tests after storing seeds for a few weeks at room temperature. This is not an accurate test as 'after-ripening' can occur at room temperature.

Q3: *What should I use to germinate: Naked or intact seeds?*

A3: Intact seeds (ie. natural dispersal unit) should be used. For example, turnip weed is dispersed in round siliques; therefore, siliques should be used to test germination. Removing the silique and using naked seeds results in very high germination. In natural conditions, the silique deteriorates slowly and so a staggered germination is observed.

Q4: *What kind of seeds should I use in the seed bank persistence study?*

A4: Fresh, intact and viable seeds should be used in these studies. Sometimes, researchers can take weeks or months to count seeds and then bury them for their studies. This is not correct. Seeds after-ripened at room temperature may have different dormancy levels than seeds after-ripened in natural conditions. Before placing seeds in the field, an initial germination test should be conducted to determine the dormancy level in fresh weed seeds.

Q5: Am I using weed names correctly?

A5: In my view, we should be using names which are understood by both growers and agronomists. The common names are different in various countries. For example, awnless barnyard grass in Australia is junglerice in the US. But researchers should know the Latin names of weeds. In illustration, there is often confusion about brassica weeds such as wild turnip (*Brassica tournefortii*); turnip weed (*Rapistrum rugosum*); wild radish (*Raphanus raphanistrum*); Indian hedge mustard (*Sisymbrium orientale*); African mustard (*Sisymbrium thellungii*); and, London rocket (*Sisymbrium irio*).

Q6: *What temperature and light conditions should I use?*

A6: Fluctuating temperatures should be used to test germination as constant temperatures are not encountered in most weed situations. In some cases, lower germination is found at constant temperatures compared with alternate temperatures. Constant temperatures are used when the aim is to find a base temperature for germination. Similarly, continuous light conditions should be avoided. Complete dark conditions can also be used to simulate seeds buried in the soil.

Q7: *How should seeds be cold stratified?*

A7: For cold stratification, imbibed seeds should be used. Using dry seeds may result in a change in seed moisture, which can affect seed viability. The temperature for cold stratification should be between 0 and 5°C. Seeds cannot be cold stratified in a freezer. ■

Crop variety performance data for more informed sowing programs

GRAIN growers across the nation are being provided with important new data to inform their crop variety choices for the 2019 season. Harvesting of the extensive winter crop variety trials conducted through the GRDC National Variety Trials (NVT) program is now complete and data from those trials is being made available to Australia's growers and their advisers.

GRDC NVT Acting Senior Manager, Rob Wheeler, says single site results from successful trials in 2018 have been finalised and this data has been fed into multi-year, multi-environment trial (MET) variety performance analysis.

"These multi-year, rolling datasets for all crops and growing regions will provide growers with the most valuable information to support their decision-making around what to sow this year," Rob says. "Long-term MET results are the most accurate and reliable means of interpreting variety performance across sites and years."

Instructional videos available

To further support growers and advisers, the GRDC has produced new instructional videos on 'how to interpret NVT data (long-term yield results) using the NVT website' and 'how to navigate NVT's website'. The videos can be viewed via the GRDC's YouTube channel at http://bit.ly/2W75A5U.

NVT Systems Manager Neale Sutton demonstrates how to interpret trial data on NVT's website, to help growers find the most suitable crop performance data for their own situation.

Rob says it is important that growers factor long-term analysis of trials into their variety selection considerations, rather than results from a single year.

"This is especially important after a year such as 2018 where – in many regions – the season was far from normal."

Rob says, similar to the experiences of many growers in parts of Queensland, New South Wales, Victoria and South Australia, some NVT trials were impacted by drought, frost, wind and other climatic events.

"But despite what was an incredibly tough season in some areas, the 2018 NVT program overall was a productive one, with a great proportion of the trials generating valuable data that has now been published."

GRDC's NVT Acting Senior Manager, Rob Wheeler, says harvest of the 2018 winter crop variety NVT trials is now complete and data from those trials is being made available to inform growers' variety choices in 2019. (PHOTO: GRDC)

Look at quality attributes as well as yield

Growers and advisers are encouraged to base their variety decisions on not just yield results but also market receival quality data. "Simply focusing on yield does not provide growers with a reliable indication of which varieties may potentially offer the best returns – the quality of the grain harvested is also an important factor," Rob says.

Planning for the NVT program for 2019 is well underway, with the number of trials expected to be more than 600, as per previous years. The largest co-ordinated field trial network of its kind in the world, NVT is a 100 per cent GRDC investment that is fully administered by the GRDC on behalf of Australian grain growers and the Australian Government.

A national program of comparative crop variety testing with standardised trial management, data generation, collection and dissemination, NVT seeks to assist growers to optimise the profitability of their farming systems through choosing the most appropriate varieties for their growing environments.

Rob says NVT represents a huge logistical undertaking given it evaluates varieties for the 10 major crop types – wheat, barley, canola, chickpea, faba bean, field pea, lentil, lupin, oat and sorghum – within hundreds of trials across the country.

"About 2000 near-release or released varieties are evaluated each year, generating highly valuable comparisons for variety agronomic performance, grain yields, disease and pest resistance and physical grain quality traits," he says. "NVT accepts lines into the program for testing two years prior to their commercial release. This ensures sufficient data is available for growers on newly released varieties to make informed decisions."

Data analysis for NVT is conducted by a team of statisticians through the Statistics for the Australian Grains Industry program.

Rob says with 2018 NVT results reflecting what occurred around the country in terms of the variable season, some trial results were compromised by these conditions at a number of sites. "Data from those compromised trials is presented in a 'quarantined' report. This report is published on the NVT Online website to provide growers with a transparent account of the fate of unreleased but not abandoned NVT trials, but the data is of no value for the purposes of head-to-head variety comparison."

Meanwhile, a team of dedicated GRDC NVT regional staff has now been appointed – enhancing co-ordination of trials and extending NVT's reach and presence in the regions.

NVT regional staff are Peter Bird (west), Laurie Fitzgerald (north) and Rob Wheeler (south). Ben O'Connor provides further regional support for north eastern Victoria and southern New South Wales. Contact details for regional staff can be found on the NVT Online website.

Rob thanks the many trial co-operators (landholders) across the country who continue to support the NVT program by allowing trials to be conducted on their properties. Trial results and analysis can be viewed at *www.nvtonline.com.au*

New and improved AgriClime offer opens for 2019

REGISTRATION is now open on a new AgriClime offer for 2019, designed to give growers the confidence to invest in a better crop. Growers who spend $15,000 on two or more participating Syngenta products are eligible for up to 30 per cent cash-back, if the minimum rainfall threshold isn't met for their nominated paddock. Under the old offer this was capped at 15 per cent.

The chance of receiving a cash-back has also improved. Based on 20 years of rainfall data, the chance of a cash-back is now 1-in-5 years, instead of 1-in-10 years previously.

"We truly believe in AgriClime as a tool to help growers better manage risk and to provide them the confidence to invest in a better crop through the use of our quality products," Angus Rutherford said.

"We want growers to have a bumper season, every season, but in case this doesn't happen we want to share this risk with growers."

More than $850,000 has been made in cash-back payments to growers since the program was introduced in 2016.

Last year, one-in-four registered growers in NSW and Victoria received a cash-back. In fact, 89 per cent of all AgriClime payments nationally were made to those NSW and Victorian growers, where the drought was at its worst*.

But Angus said he understood there were growers who were disappointed they didn't receive a cash-back.

"There were two main factors, firstly, the rain that arrived in October in some areas – that was sadly too late for the crops – but pushed growers over their rainfall threshold," he said.

"Secondly, the grid cell size for rainfall recording – 25 km x 25 km (125 km²) – under the old offer was too big, meaning it was not always reflective of on-farm rainfall.

"We know some growers were unhappy and that's why we have made key changes to the 2019 program."

Accordingly, the grid cell size for 2019 has been reduced to 5 x 5 km:

As always, AgriClime is FREE to register, includes 16 products from the Syngenta range and is quick and simple on our new platform.

Growers or their advisors simply need to nominate whether to participate in the August-September 2019 offer, OR the September-October 2019 offer.

"We would love to see all growers back for AgriClime in 2019 as we look to give you confidence to invest in a better crop," Angus said.

AgriClime products: Affirm, Amistar Xtra, Axial, Boxer Gold, Cruiser 350, Dual Gold, Karate Zeon, Miravis, Moddus Evo, Spray.seed, Talinor, Uniform, Vibrance.

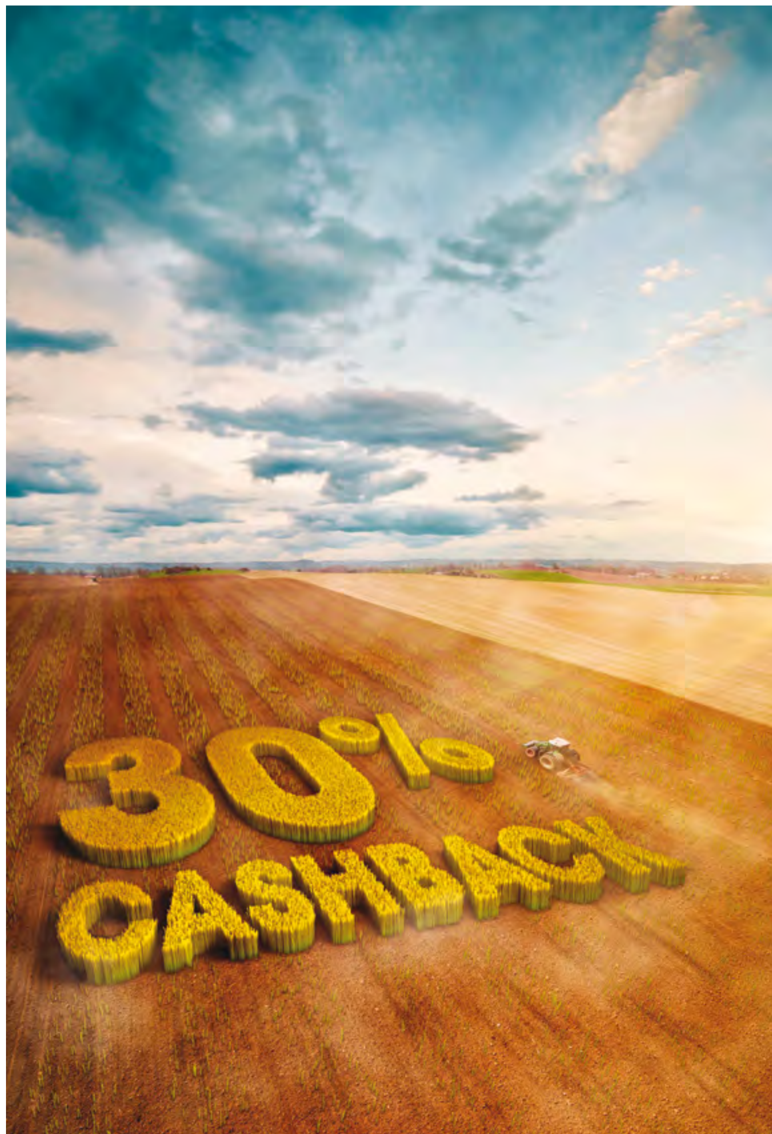
New: Inclusion of Axial Xtra, Cruiser OptI and Elatus Ace (pending APVMA registration).

Visit *agriclime.syngenta.com.au* for more info.

***No registrations were received from Queensland growers in 2018.** ■

AT A GLANCE – 2019 CHANGES TO AGRICLIME…

- The Rainfall Threshold has been changed to be a 1 in 5 year low-rainfall event (previously 1 in 10), based on 20 years of historical data, meaning there is a greater chance of a payout
- A payout is triggered at an entry point (the Rainfall Threshold) and maxes out at an exit point (the Exit Point) whereby a maximum cash-back of 30 per cent is paid (previously 15 per cent).
- The payout works on a linear scale, so the less rainfall the more cash-back
- The Grid Cell size is now 5 X 5 km² or 25 km² meaning that the Grid Cell is smaller and rainfall data is much more accurate to a farm level.



Have the confidence to invest in a bumper crop under the AgriClime program.

New herbicide resistant hybrid canola with Chinese approval

MARKET-LEADING seed producer Pacific Seeds has announced plans to launch two new canola varieties to the Australian market, following the Chinese government's approval of the Bayer-developed TruFlex herbicide resistant trait.

TruFlex is the first new herbicide-resistant trait offering since Monsanto – which was recently acquired by Bayer – launched the Roundup Ready herbicide trait in 1996.

It offers canola growers a wider weed spraying window, extending beyond the current six-leaf stage up to first flowering.

Pacific Seeds managing director Barry Croker said Pacific Seeds had taken a commercial decision to integrate the Truflex trait and conduct seed production prior to approval from China.

"We wanted TruFlex hybrid seed ready for the growing season in April as we anticipated approval from China would come through early this year, but this meant we needed to start production in mid 2018," Barry said.

"We're pleased that the approval has come through, and as we have just harvested good pilot quantities of seed in Chile, the seed will be ready for sale with the TruFlex trait following the appropriate processes and logistics are completed.

First big innovation in 25 years

"This is the first big innovation in extended spray application technology since 1996, farmers have been crying out for an innovation and we're so excited to be able to offer the latest technology now, responding to the demand from our customers.

"By providing an extended the spray window, the TruFlex trait offers more flexibility for growers and improved weed management.

"Effective weed management is an essential part of delivering, higher yields and cleaner paddocks.

"China is Australia's largest export market for canola, so this approval was essential for growers," Barry said.

"Our customers have been demanding this product for some time, and we have listened ensuring Australian canola growers can start to reap the benefits from TruFlex canola during the 2019 season."

Pacific Seeds managing director Barry Croker.

Pacific Seeds will have two new hybrids with the Truflex trait available for the 2019 plant;

- Hyola 410XX which is a straight Truflex hybrid; as well as,
- Hyola 530XT which is an Australian first stack which offers both the Truflex trait as well as triazine tolerance.

"We're expecting massive demand this season for TruFlex seed, which offer farmers more flexible and more effective spray-resistance for better weed management as part of their IWM programs," Barry said. ■

Aftermarket replacement press wheels

THE Manutec range of aftermarket press wheels has continued to grow. This year specialised press wheel parts have been released to suit North American seeding equipment. They are designed specifically to suit Australian farming conditions.

The new press wheel parts are available for seeding equipment including: John Deere (1830/1835); FlexiCoil (5000/5500); Bougault (5810); John Deere (1870); Morris C1/C2; Bourgault (3320/2420); Seedhawk; Flexicoil (PD5700); DBS/AUSPLOUGH; Flexicoil ST820; and, John Deere 1860/1890

Parts available include replacement press wheel tyres for the air hoe drills, complete replacement wheels for the precision seeders and replacement gauge wheels, hubs and discs for the disc seeders. The replacement parts have all been designed with the extra durability required for farming in Australian conditions and new tyre shapes have also been developed to suit a wider range of farming conditions.

Manutec also has a large range of parts available to suit all Australian manufacturers including new specialised aftermarket tyres to suit the DBS/Ausplough. As the take up of this seeding method increases so to does the range of tyres that Manutec has available to suit most Australian and imported machinery. Existing press wheel systems that have been optimised to single narrow row seeding can now be easily converted to suit spread row and split row seeding. This allows farmers to maximise their investment by ensuring that the press wheels match the paired row boots.

Manutec's own range of press wheels and press wheel assemblies are now available with the zero maintenance agri-hub option. The agri-hub option is a completely sealed, maintenance free hub specifically designed for use in tillage.

The agri-hub press wheel is available as a standalone wheel or as part of a complete press wheel system and will suit those farming larger acreages looking for reduced maintenance costs.

For more information call Manutec on 08 8260 2277 and ask to speak to Mick or Dan. Also visit *www.manutec.com.au* ■

Improve canola yield with next generation foliar fertiliser

YARA Australia will introduce YaraVita Brassitrel DF in 2019, a multi-nutrient foliar fertiliser that has been developed to supply key nutrients during important growth periods for brassicas and canola crops. Each crop has a specific nutrient requirement and certain key nutrients are more important to the development of some crops than others.

Based on this knowledge, Yara developed YaraVita Brassitrel DF and tested it's performance with comprehensive glasshouse and field trials. International field trials conducted at Bainton in north east England showed a 16 per cent increase in grain yield over the untreated control (Figure 1) and 14 per cent increase in oil yield over the untreated control (Figure 2).

FIGURE 1: YaraVita Brassitrel DF application results in higher grain yield over untreated control

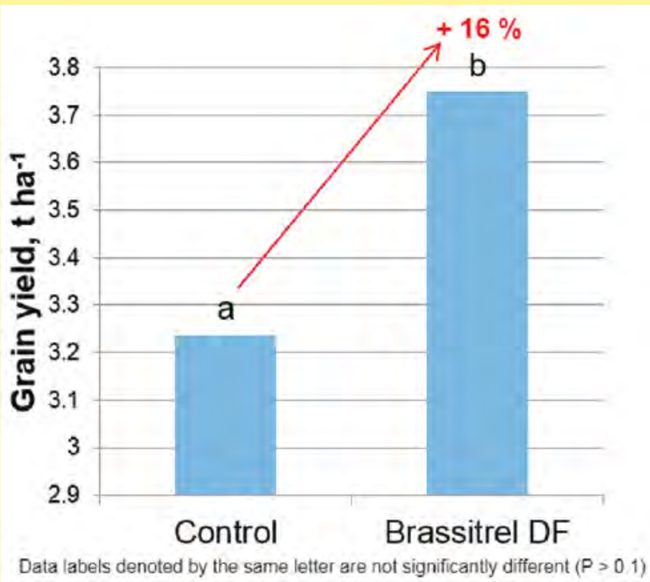
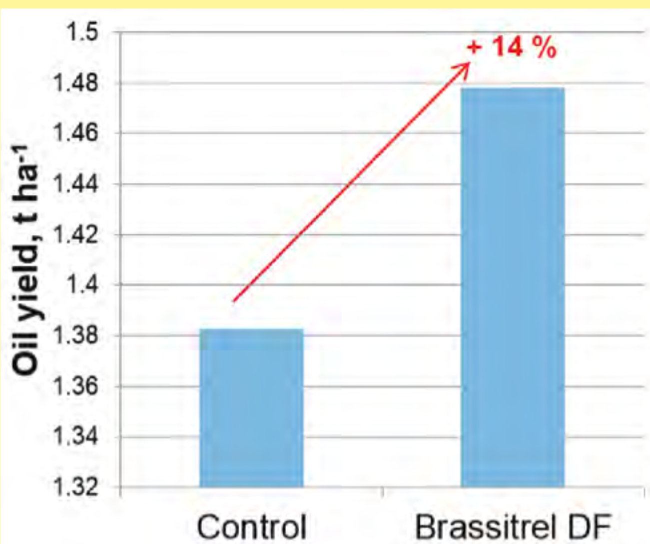


FIGURE 2: YaraVita Brassitrel DF application results in higher oil yield over untreated control



"The YaraVita development team have been able to produce Brassitrel as a DF (Dry Flowable) without compromising the complete foliar formulation package. Recent inspections of our canola demonstration sites revealed good crop responses to the Yara program," said David McRae, Yara Australia Agronomy and Crop Solutions Manager.

"YaraVita Brassitrel DF is a great product that not only improves yield. It also has great application benefits."

The benefits are as follows:

- 10 kg bags makes it easy to pour, measure and mix the microgranule quickly into the spray tank with minimal dust, reducing filling downtime.
- A controlled particle size gives quick and long lasting nutrient uptake. This reduces the need for repeat applications, saving both time and money.
- Contains its own wetting agents, sticking agents and absorption agents. The combined effects of these agents helps to increase nutrient uptake.
- Rainfast – once spray droplets are dry on the leaf surface the application is safe and will not wash off, keeping applied nutrients where they can be utilised by the developing crop.
- A wide range of tank mix compatibilities makes it easy to co-apply with agrochemicals, saving both time and money – supported by *Tankmix* (free app available to download).
- Better nutrient value proposition for growers.
- No drum rinsing and disposal.

YaraVita Brassitrel DF will be introduced by Yara Crop Nutrition in Australia in 2019 to replace the current SC formulation – Brassitrel Pro.

For more information, contact your local sales agronomist at 1800 684 266. Contact details are also available at *www.yara.com.au* ■

Field trials conducted in Australia to test the new foliar fertiliser have shown yield increases.

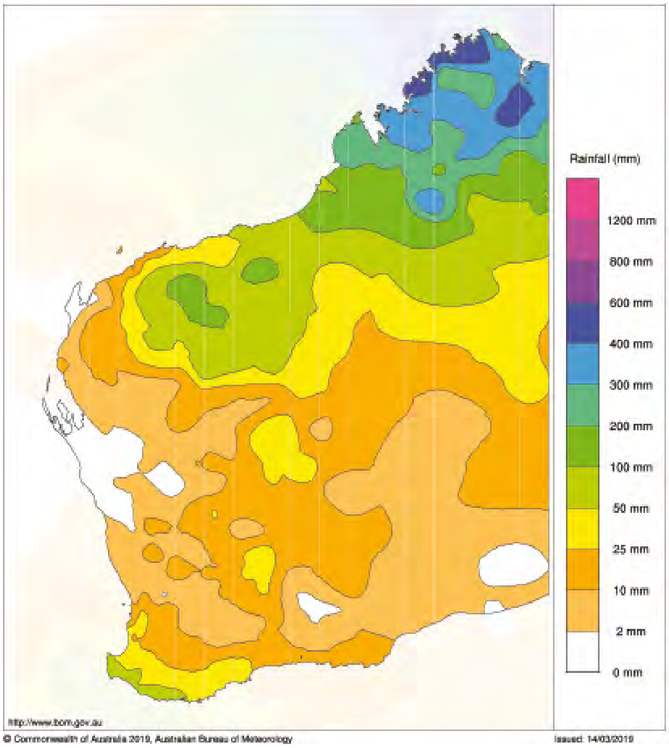
District Reports…

March–April 2019

Western region

Western Australia rainfall totals (mm) January 1 to March 14, 2019

Australian Bureau of Meteorology



NORTHERN DISTRICT

It has been a very dry summer for most growers in the WA Northern Ag region. The odd strip that did have storm cells move over them have been sprayed. This dry summer has given most growers a chance to enjoy a summer break – and many have even managed an extra week.

The region has just had four to five days of continuous cloud cover with a mid level cloud band but almost no rain at all was recorded. Hopefully we can score a good rain event in the next couple of months to build up some stored soil moisture and to provide a weed knockdown opportunity.

The Armadillo spader in action doing trial strips on 'Moonyoonooka', the property of our district reporter, Peter Norris. A 400 plus horsepower Cummins engine drives the two spader rotors that are each 3 metres wide giving a 6 metre cut. The machine is ripping to around 450 mm and spading to 350 mm.

Peter Nunn checking the spading depth of the Nufab Armadillo spader machine. Peter is the owner of Nufab Equipment, a local Dongara-based engineering company.

Most planning and budgeting has been done and many growers are now out and about getting prepared for the coming season. Spreading lime, deep ripping and preparing machinery for crop planting are the main activities on grain farms.

Livestock producers are busy keeping feed up to their animals while GRDC Crop Update meetings have also kept the calendar pretty full with most growers having attended a meeting or two in recent weeks.

We will happily take any rain from now on – the more the merrier at this time of year. Bring it on!

Peter Norris
Agronomy For Profit and Synergy Consulting, Geraldton
March 12, 2019

SOUTH COAST

Seasonal conditions on the South Coast have remained very dry over the past two months with less than five mm of rain recorded. Most growers have continued with soil amelioration projects, liming, gypsum, deep ripping, delving and clay spreading.

Domestic and stock water is starting to become an issue with some dams drying up and rain water tanks near empty.

District Reports…

Deep-ripping underway with a TTQ Super Raptor at Daybreak Cropping Farm, West River, 240 km west of Esperance. Nicky Tesoriero (left) from Agronomy Focus checks on progress with farm manager, Levis MacKenzie.

Growers are still optimistic about the upcoming winter crop, but like most across Australia, they would welcome some good season-opening rainfall.

Quenten Knight
Agronomist, Agronomy Focus, Esperance
March 14, 2019

Southern region

SOUTH AUSTRALIA SUMMARY

Due to favourable late 2018 spring conditions on Eyre Peninsula and central and southern Yorke Peninsula, South Australia's 2018-19 winter grain harvest production estimate is now slightly above earlier expectations at 5.3 million tonnes. Many farmers also cut crops for hay due to the drought and the very strong demand for stockfeed.

While the harvest estimate is significantly under the 10-year long-term average of 7.9 million tonnes, the farm gate value of around $2 billion is higher than in 2017–18.

Due to variable rainfall, soil type and frost damage, the harvest was very patchy with some farmers with record crops and some not harvesting at all.

Areas such as Southern Yorke Peninsula, Lower Eyre Peninsula and the Mid and Lower South East experienced average to above average yields.

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)	2019 rainfall to date (mm)	Summer 25yr Annual Average (mm)	Summer 2018–19	Autumn 25yr Annual Average (mm)	Autumn 2019 to date	Winter 25yr Annual Average (mm)	Winter 2018	Spring 25yr Annual Average (mm)	Spring 2018
Emerald Qld	564	35	251	52	106	2	67	29	125	113
Toowoomba Qld	679	39	276	73	138	15	86	36	180	184
Roma Qld	579	1	256	36	119	0	75	34	134	106
Goondiwindi Qld	619	16	253	66	123	4	98	45	147	174
Narrabri NSW	621	20	217	69	119	7	123	47	162	149
Gunnedah NSW	627	26	211	65	108	5	126	42	183	207
Dubbo NSW	588	83	184	117	125	0	129	57	152	166
West Wyalong NSW	437	72	118	84	79	8	120	60	122	86
Wagga Wagga NSW	531	59	134	110	109	5	147	77	141	149
Swan Hill Vic	308	15	69	57	64	0	87	59	88	41
Bendigo Vic	490	19	100	60	105	1	158	128	128	61
Horsham Vic	365	14	76	41	71	3	120	109	99	47
Lake Bolac Vic	506	27	108	72	103	7	153	165	142	73
Murray Bridge SA	358	8	66	30	80	2	120	83	94	47
Kadina SA	327	2	60	9	76	0	110	76	82	58
Cummins SA	390	3	51	6	89	1	174	241	76	48
Esperance WA	618	8	90	37	136	7	251	284	140	146
Wagin WA	391	19	50	7	90	17	165	213	85	61
Northam WA	407	4	61	32	87	2	189	263	80	55
Mingenew WA	347	0	33	0	86	0	171	203	57	40
Moora WA	385	2	46	6	82	0	189	286	68	65
Mullewa WA	320	1	56	12	90	0	131	165	43	24

Last rainfall reading March 14, 2019.

District Reports…

March–April 2019

Barley yields were higher than expected in a number of districts, while wheat yields were lower, mainly due to drought and frost.

Pasture feed in most districts has been exhausted and ground cover levels are very low, increasing soil erosion risk.

Primary Industries and Regions SA (PIRSA)

VICTORIA SUMMARY

Winter crop production in Victoria in 2018–19 is estimated at around 3.7 million tonnes – the lowest since 2015–16. The area harvested for grain fell by more than 10 per cent because a number of wheat and canola crops were cut for hay.

Wheat production is estimated at around 2 million tonnes with the average yield at 1.39 tonnes per hectare.

Barley production was around 1.1 mt with a 46 per cent decline in the average yield to 1.43 tonnes per hectare.

Canola production fell to 300,000 tonnes at an average yield of 1.0 tonne per hectare.

ABARES Australian Crop Report
February, 2019

VICTORIAN MALLEE

Many Victorian Mallee farmers are continuing to see weeds germinate as a result of the large December rainfalls, but these farmers are on a mission to conserve sub-soil moisture. Consequently, some paddocks have been sprayed for the third or fourth time to control heliotrope and roly-poly. Sprayers won't have much downtime this year as it's only a matter of weeks before pre-emergent sprays are applied.

Farm plans are being confirmed ahead of the 2019 winter cropping season, with farmers carefully weighing up the best ways to manage weeds, nutrition, diseases and profits through the rotation of crop types and variety selection. Soil sampling is assisting farmers and their agronomists make these decisions – they are keen to know how much moisture and nitrogen is currently available for this year's crop.

All eyes are turning to the skies again, and the words 'autumn break' are impossible to avoid as you walk down the street. The traditional Anzac Day sowing deadline is looming. Some farmers will wait for the opening rain to commence sowing, while others will sow earlier. It's a decision that farmers are now making – assessing when to start sowing to get as much crop in during the optimal sowing window to minimise the yield penalties of sowing too late.

Final pre-sowing preparations are underway with many cleaning last year's cereal seed and ordering new canola seed. Fertiliser, mainly urea, super and MAP, is also being ordered, and the freight coordinated. Some trucks are getting more use collecting this year's fertiliser than they did delivering last year's harvest!

There is an increasing trend in the region to put more fertiliser in up-front, especially among barley growers, due to the limited opportunities available later in the season.

Maintenance and servicing of tractors and seeding equipment is also keeping farmers busy, with most spending a lot of time under the bar making sure that everything is ready to go for when they believe is the best time to be sowing.

Soil samples in the Mallee are showing promising sub-soil moisture levels thanks to good December rain and diligent summer weed control.

Mixed farmers are preparing for April lambing, and are keeping a close eye on the nutrition available to their gestating ewes. Hopefully, lambing percentages will be high, despite the hot weather during the joining period. Farmers who have bought in sheep to run on their stubbles over the summer are likely to be selling in preparation for sowing.

Kate Maddern
BCG Research Agronomist, Birchip
March 14, 2019

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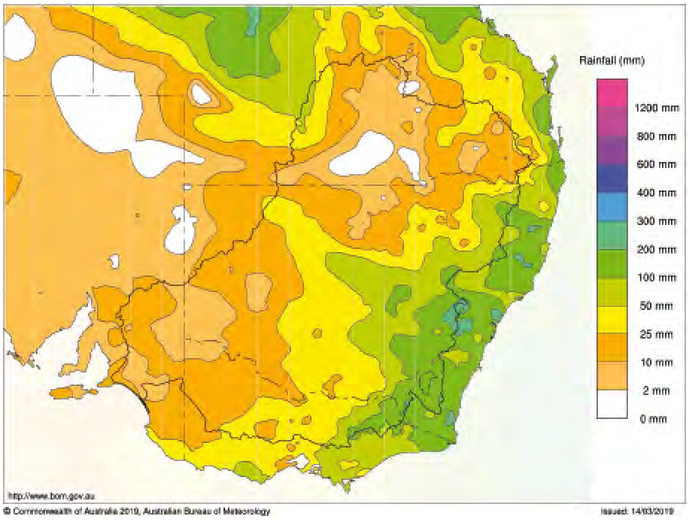
District Reports…

March–April 2019

Murray–Darling Basin rainfall totals (mm) January 1 to March 14, 2019

Australian Bureau of Meteorology



Northern region

NSW SUMMARY

Seasonal conditions during December and January were generally unfavourable for summer crop planting. Below to very much below average December and January rainfall and prolonged heatwave conditions depleted soil moisture levels and reduced yield prospects for dryland summer crops.

The area planted to summer crops in New South Wales is estimated to have decreased by 32 per cent in 2018–19 to 419,000 hectares, reflecting low supplies of irrigation water and insufficient soil moisture in many regions for planting dryland crops.

Total summer crop production is forecast to fall by around 45 per cent to 1.2 million tonnes.

Area planted to grain sorghum in NSW is estimated to be around 150,000 hectares, 17 per cent below the 10 year average. With well below average December and January rainfall, and prolonged heatwave conditions in late December and January, yields are well down. Sorghum production of around 375,000 tonnes is estimated.

The area planted to cotton is estimated to have declined by 44 per cent to 174,000 hectares. A corresponding decline in production to around 1.6 million bales is expected.

ABARES Australian Crop Report
February, 2019

QUEENSLAND SUMMARY

The area planted to summer crops in Queensland in 2018-19 was estimated at 606,000 hectares. The area planted to cotton declined to 106,000 hectares and a harvest of around 925,000 bales is expected.

The area planted to grain sorghum was around 385,000 hectares in 2018–19, which is below the 10-year average of 407,000 hectares. Production is forecast at 924,000 tonnes of sorghum with average yields down by nearly 10 per cent.

ABARES Australian Crop Report
February, 2019

DARLING DOWNS

January and February produced no rain across the Darling Downs and that has left the region's past three months' rainfall at 20 per cent of the 30 year average – and this is following on from a very dry 2018. Mid-March is now producing record high temperatures to finish off the driest and hottest summer most locals can remember.

Summer crop

Yields have been determined more by the amount of stored moisture in the paddock profile than choice of variety. And the moisture levels ranged from some good, to a lot of average, and way too many poor profiles at planting. The lack of in-crop rain left crops growing on the stored moisture alone.

District Reports…

March–April 2019

Sorghum has ranged from failed crops, crops cut for hay or silage, and highly variable. The Dalby area was lucky to receive some patchy storm rain on December 20 resulting in local sorghum crops producing 4 to 6.5 tonnes per hectare with a few as high as 8.0 tonnes. The average sorghum yield for the Downs was around 3.5 tonnes per hectare.

The sorghum screenings have also had a large range – generally from 2 to 30 per cent – with a few paddocks as high as 40 per cent.

Deliveries to date indicate that around 44 per cent of the sorghum harvested is going Sorghum 1 with 54 per cent in the Sorghum 2 bin. There have also been some Sorghum 3 loads.

Shorter season sorghum varieties have produced more from the limited moisture, but with the seed shortages at planting, there were plenty of paddocks planted with varieties not ideally suited to the season.

Harvest occurred earlier than usual with charcoal rot causing lodging due to the dry finish. Many growers harvested at up to 20 per cent grain moisture to get the crop in before it went flat. The grain was then aerated in silos to get the moisture down. Heliothis had to be controlled on the spring planted sorghum while midge attacked the small area of summer planted crop.

There was a small area of irrigated corn grown for silage or gritting. There were also a few irrigated mungbean fields. Dryland corn has not yielded with this season's different conditions.

The bulk of the limited irrigation water available went on cotton, although many growers finished up to two irrigations short, and some water was used on the vegetables in the Eastern Downs.

The mungbean plant was reduced to about 40 per cent of the usual area, and all were December/January planted. They had no in-crop rain and were harvested very carefully, being so short, with well below average yields of 0.3 to 1.0 tonnes per hectare. The few irrigated mungbean crops are expected to reach 2.0 tonnes.

Corn being harvested on the Darling Downs.

Sunflowers have filled heads above expectations with lower plant populations, and these crops should be harvested soon.

Winter crop outlook

The outlook is not good with no better than average rain forecast and little chance of drought breaking falls. But for the few fallow paddocks with moisture, there are fair prices on offer for winter cereals and chickpeas. There is little interest in faba beans or canola.

The winter crop area will be back because of the lack of stored soil moisture, the very large area sown to sorghum this summer, and at this stage, very little chance of double cropping. Let us hope the weather surprises us.

Hugh Reardon-Smith
Agronomist – Landmark, Pittsworth
March 14, 2019

It was a very early harvest this summer on the Darling Downs with sorghum stubble showing some lodging, and dry, dry soil.

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