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FRONT COVER

Rutherglen bug (RGB) is a sap sucking insect pest well known for the damage it can inflict on summer crops during grain fill. But recent DAF Qld research has found that RGB can also be a problem in the establishment phase of these crops. See article Northern Focus page i.
(PHOTO: Keith Power)

Contents

Focus Sections

Southern Australia Focus

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

Northern Focus

Covering Northern NSW and Queensland

The pre-eminent pre-emergent.

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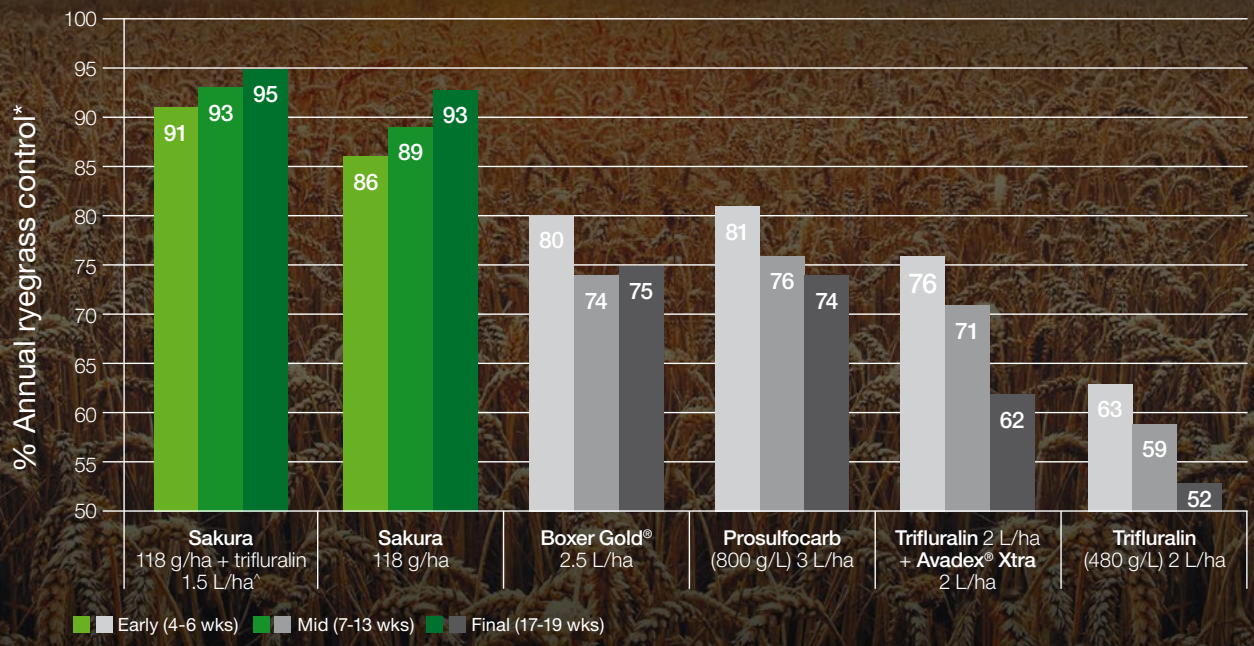
The long residual control of Sakura makes it a standout

Control of annual ryegrass across 7 trials - WA (Coorow, Pithara, Cunderdin, Nugadong), Vic (Pyramid Hill, Wedderburn), NSW (The Rock)



Trial IDs: WE05, WE06, WE07, Liebe Group Nugadong 16, VD12, VD13, NA11. All trials conducted in 2016#.
*Some trials, weed counts and others are control ratings. ^Trifluralin (480 g/L) applied at 2 L/ha in trials VD12, VD13 and NA11.
#Final assessments only for WE05, WE06, WE07, Liebe Group Nugadong trial sites.

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TPAGTA-JND59887-7R8R-AG

Editorial... Lloyd O'Connell

WITH forecasts of around 35 million tonnes for this year's national winter crop – a drop of around 40 per cent on last season's once in a farming generation result – Australia is doing its bit in reducing world grain production, and particularly the mountain of wheat in storage around the globe. And according to the latest USDA figures, so too are US farmers with an estimated 19 per cent fall in wheat production.

But it's the Black Sea region wheat producers who are spoiling the party. In Russia, Ukraine and Kazakhstan, 2017-18 total wheat production is forecast to be 123.5 mt, up around 8 per cent on last year. Wheat production in the EU and India is also tipped to increase. The net effect is that the world's ending stock of wheat is projected to be a record 268 mt.

At first glance, you'd be forgiven for seeing this as a big negative for wheat price with a roll-on effect on the value of other international grain prices. Not so, according to the USDA at least! They are projecting 18 per cent higher average wheat prices for US farmers on the back of surging world wheat consumption and trade.

A quick back of the envelope analysis tends to also support this optimism. Ten years ago, global wheat production was around 685 mt, the world consumed 650 mt of that and traded another 130 mt or so. Global ending wheat stocks sat at around 175 mt. Roll forward to current year projections and the world will produce about 10 per cent more wheat than in 2008–09 but we'll consume 14 per cent more than we did 10 years ago. Ending stocks will increase to a record 268 mt.

What is often overlooked about ending wheat stocks is where they are held today compared to 10 years ago. Among the traditional wheat exporting countries, including the Black Sea, things haven't changed much with these exporters collectively holding around 75 mt (of the record 268 mt). China will hold almost half of the world's ending wheat stocks. And take China out of a global stocks-to-use calculation for wheat – which is a reasonable thing to do because China is a relatively small player in global wheat trading terms – and you come up with a STU ratio of 22 per cent – a smaller number than 10 years ago!

AUSTRALIAN GRAIN
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In this issue...

Herbicide options for control of black pigweed in pigeonpea

By Gulshan Mahajan[1], Rao Rachaputi[1] and Bhagirath S. Chauhan[1]

AT A GLANCE....

- Black pigweed is a troublesome weed in pigeonpea crops, and it could reduce the yield of pigeonpea significantly.
- Pre-emergence application of pendimethalin (450 g/L) at 2.0 litres per hectare reduced the biomass of black pigweed by 87 per cent and resulted in a 32 per cent increase in seed yield as compared to the untreated control.
- Post-emergence application of imazapic (240 g/L) at 437 ml per hectare reduced the biomass of black pigweed by 79 per cent and resulted in 60 per cent increase in seed yield as compared to the untreated control.

PIGEONPEA is familiar to many northern region growers as it is often used as a trap crop for insect management in cotton production. But outside of the north, pigeonpea (*Cajanus cajan*) is relatively unknown. On the international stage it is a much more prominent crop.

Pigeonpea ranks sixth in production of dryland legumes in the world and it is consumed by billions of resource poor farmers in the tropics, subtropics and semi-arid tropics, as a vegetable protein. The seed is eaten as a green vegetable or split dry grain popularly called 'dhal' which is a major supplement to energy rich cereal diets in a mainly vegetarian population.

The vegetative parts of the plant are rich in fibre and used as rations in stockfeed.

A luxuriant growth of pigeonpea. This field was treated with imazapic at 437 ml per hectare for excellent pigweed control.

Black pigweed infestation in pigeonpea.

Being a legume, pigeonpea can fix atmospheric nitrogen for its own use as well as contribute some residual nitrogen (40–60 kg N per hectare) for the subsequent crop. The vigorous root system (up to two metres deep) of pigeonpea enables tapping of water and nutrients from deeper soil profile while sequestering carbon.

Australian growers showing interest

In Australia, farmers have recently shown interest in growing pigeonpea as a food crop because of high export price, and it is extremely productive under low soil moisture and fertility conditions.

Compared to other legumes, the relatively slow growth of pigeonpea keeps it at a competitive disadvantage against the rapid growth of summer weeds, particularly at early stages. Black pigweed (*Trianthema portulacastrum*) is one of the most troublesome weeds infesting a number of summer crops – including pigeonpea. Its high infestation in the field could reduce the seed yield significantly.

Earlier work suggests that the critical period of crop-weed competition in pigeonpea is up to six weeks and uncontrolled weeds during this period can reduce the seed yield of pigeonpea significantly. Choices of herbicides for weed control in broadleaf-pulse crops are limited, and soil moisture conditions in dryland limit the efficacy of pre-emergence herbicides.

Under these situations, use of post-emergence herbicides is one of the options that may be used as a sole treatment or in sequential spray after pre-emergence herbicides for alleviating the problem of weeds.

For post-emergence herbicides the major influences on effective weed control will be the dose and time of application, herbicide efficacy and crop growth stage.

A wrong choice of a herbicide and an overdose of post-emergence herbicides may cause phytotoxicity to the crop due to the juvenile nature of pigeonpea plants. The objective of our recent research was to evaluate the effects of pre and post-emergence herbicides on black pigweed suppression and seed yield of pigeonpea. Information generated from this study will help in registering effective herbicides for weed control in pigeonpea.

TABLE 1: Herbicides' effect on per cent reduction in biomass of black pigweed at 50 days after sowing and per cent increase in yield of pigeonpea as compared to the weedy plots (each value is an average of three replications)

Treatment	Reduction in weed biomass (%)	Increase in seed yield (%)
Weedy (untreated control)	—	—
Pendimethalin (450 g/L) 2.0 L/ha	81.4	31.7
Pendimethalin (450 g/L) 2.5 L/ha	87.1	26.4
Imazapic (240 g/L) 350 ml/ha	37.1	26.4
Imazapic (240 g/L) 437 ml/ha	79.0	59.9
Aciflurofen (224 g/L) 1.5 L/ha	37.8	9.2
Aciflurofen (224 g/L) 1.9 L/ha	70.2	8.4
Bentazon (480 g/L) 2.0 L/ha	30.6	19.4
Bentazon (480 g/L) 2.5 L/ha	38.8	30.0
Pendimethalin (450 g/L) 2.0 L/ha fb imazapic (240 g/L) 350 ml/ha	87.7	31.8
Pendimethalin (450 g/L) 2.0 L/ha fb aciflurofen (224 g/L) 1.5 L/ha	73.8	34.5
Pendimethalin (450 g/L) 2.0 L/ha fb bentazon (480 g/L) 2.0 L/ha	87.9	38.8

fb: followed by; DAP: days after planting; pendimethalin (Stomp Xtra); imazapic (Flame); aciflurofen (Blaze); bentazon (Basagran).

How the research was done

A trial was conducted in 2017 at the Gatton research farm of the University of Queensland to evaluate herbicide options for the control of black pigweed in pigeonpea.

Twelve treatments comprising of different options for herbicides including untreated control (Table 1) were arranged in a randomised complete block design with three replications. The herbicides were applied using a CO_2-pressurised backpack sprayer

Weed control with pendimethalin in pigeonpea.

Toxicity of aciflurofen in pigeonpea.

Patchy crop stand in weed plots.

Pigeonpea crop at maturity.

equipped with flat-fan nozzles (AIXR 11002 TeeJet air induction flat-spray nozzles, TeeJet Technologies) delivering a water volume of 100 litres per hectare.

The pre-emergence herbicide (Stomp Xtra) was applied immediately after sowing, and post-emergence herbicides (Table 1) were applied 20 days after sowing. The crop was planted on February 8, 2017 using a germplasm line introduced from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), at a seeding rate of 30 kg per hectare. The crop was planted at a row spacing of 50 cm with a tractor mounted planter and harvested on August 15, 2017.

What we found

Among different weed control treatments, black pigweed biomass varied from 37–303 g/m^2, and it was highest in the weedy plots. The pigeonpea seed yield among different weed control treatments varied from 1.6–2.6 tonnes per hectare; lowest in weedy plots and highest in the plots treated with imazapic at 437 ml per hectare.

The pre-emergence application of pendimethalin either alone or in a sequential application with imazapic or betazon provided more than 80 per cent reduction in weed biomass as compared to the weedy plots (Table 1).

The post-emergence application of benatzon could not provide good control of black pigweed as weed biomass reductions varied from 31–39 per cent as compared to the untreated control.

The post-emergence application of imazapic at 437 ml per hectare resulted in a 60 per cent increase in seed yield of pigeonpea as compared to the weedy plots due to superior weed control and provided better growth to the crop (Table 1).

But the lower dose of imazapic (350 ml per hectare) was not found to be effective compared to the higher dose of imazapic and caused only 26 per cent increase in seed yield of pigeonpea as compared to the weedy plots.

The post-emergence application of aciflurofen caused phytotoxicity to the crop, so resulted in a small increase in yield (less than 10 per cent) as compared to the weedy plots.

The pre-emergence application of pendimethalin increased the yield of pigeonpea by more than 30 per cent as compared to the weedy plots.

To sum up

This trial suggests that the infestation of black pigweed significantly reduced pigeonpea seed yield. The post-emergence application of imazapic at 437 ml per hectare provided good control of this weed and resulted in a 60 per cent increase in yield as compared to the weedy plots.

The pre-emergence application of pendimethalin also provided good control of black pigweed and resulted in increased yield by greater than 30 per cent.

The results also revealed that the post-emergence application of aciflurofen caused phytotoxicity to the crop despite improved weed control.

The results suggest that if farmers are unable to apply pendimethalin as a pre-emergent in time for weed control – or if there is low efficacy of pendimethalin due to limited soil moisture – they could opt for the post-emergence application of imazapic at 437 ml per hectare for good control of black pigweed.

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

Industrial hemp: A North American perspective

By Jerry Cherney, Cornell University, New York

AT A GLANCE

- Federal legislation now allows consumption of hempseed in Australia.
- A number of states have recently approved the regulated production of industrial hemp in the US, although federal policy still treats hemp and marijuana as the same plant.
- Canada has successfully grown industrial hemp primarily as a grain crop for almost 20 years, exporting much of the hempseed crop to the US.
- The numerous hemp promoters in the US consist of two very divergent groups, one group genuinely interested in industrial hemp production, the other group more interested in increasing the chances for legalisation of recreational marijuana.
- To maximise chances of success for a hemp industry, it appears that the focus should initially be on hempseed production, along with the development of cannabidiol production and processing.

WITH the federal legislation to allow consumption of hempseed, Australia is poised to greatly expand industrial hemp production. It may be helpful to review how this process has unfolded in North America.

Hemp has been grown for fibre or seed for thousands of years. There is a wide range of cultivars available, but hemp is generally day-length sensitive, and cultivars should ideally be developed locally to maximise performance within a given length of growing season. Hemp requires well-drained corn-growing type of soils, with nutrient requirements similar to corn.

Industrial hemp is identical in physical appearance to marijuana, but has very low levels of THC cannabinoid, and lacks any intoxicant potential.

North American history

Industrial hemp was grown for fibre in the US and Canada until the late 1930s, when hemp was banned in both countries because it could not be distinguished from marijuana. A brief revival of hemp fibre production occurred during both World Wars, primarily for maritime uses.

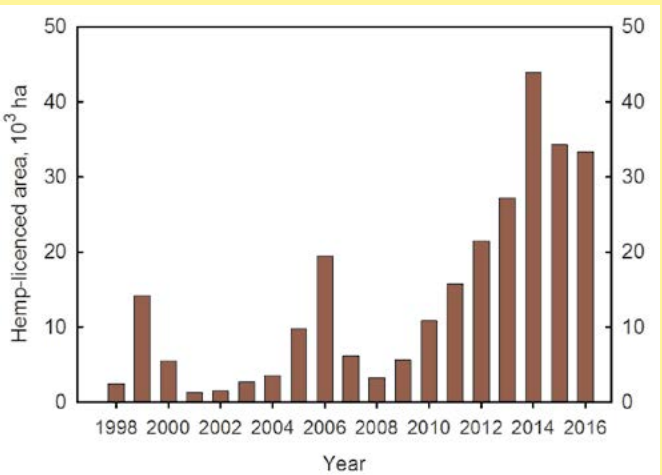
Canada began issuing licenses for commercial hemp production in 1998, and hempseed fit in well with Canada's large oilseed industry. Hemp production in Canada steadily increased until 2014, with a couple of setbacks (Figure 1). For both setbacks (1999 and 2006), production of hemp fibre increased in anticipation of fibre processing facilities, but such facilities never materialised. There was no market for the raw fibre and production crashed.

Most of the current Canadian hemp production is hempseed. Licensing and regulations for hemp in Canada have not been an impediment to Canadian farmers over the past 20 years.

Approximately half of the states in the US have passed laws permitting farmers to be licensed to grow hemp. States differ in their specific regulations. Hemp cultivation is contingent on approval of state agencies and the US Drug Enforcement Agency, since hemp remains a federally-controlled crop. Both Canada and the US use the threshold concentration of 0.3 per cent THC (tetrahydrocannabinol) to legally distinguish hemp from intoxicating cannabis relatives.

Hemp readily escaped cultivation and it gradually spread across most of North America, becoming known as 'ditchweed'. There was a major investment by law enforcement in eradicating wild hemp, even though there was essentially no risk of producing intoxication. Federal US law continues to treat hemp and marijuana as the same plant, classified as a Schedule 1 controlled substance.

FIGURE 1: Area licensed for hemp production in Canada



(SOURCE: Health Canada).

Hemp fibre

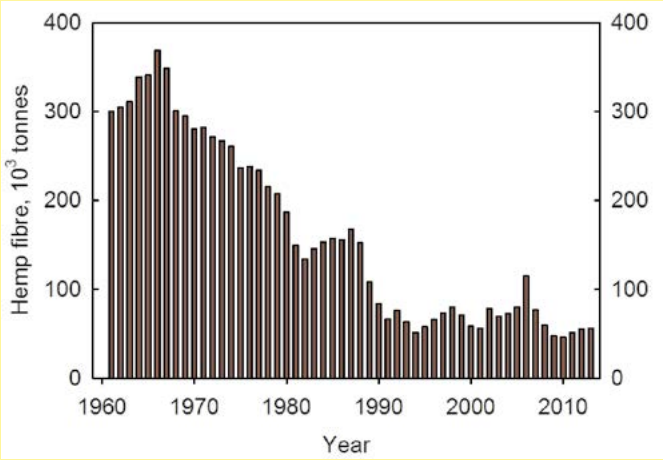
Throughout most of history, hemp production has focused on fibre. The more valuable long outer hemp fibres (phloem or bast) are separated from short inner fibres (xylem or hurds) by the process of retting, which can be done in-field, by using water, or with chemicals. Water retting is very undesirable from an environmental standpoint and is not allowed in most countries.

Bast fibres are used for papers, textiles and automotive applications, while hurd fibres often are used for animal bedding and construction materials.

Hemp has been replaced by other natural and man-made fibres for most uses, and worldwide hemp production for fibre has been relatively stagnant for the past 20 years (Figure 2).

There is a stable niche market for hemp fibre products in the textile industry, but it is not clear if the market will expand greatly in response to various hemp building construction products or biocomposites now available.

FIGURE 2: World hemp fibre production



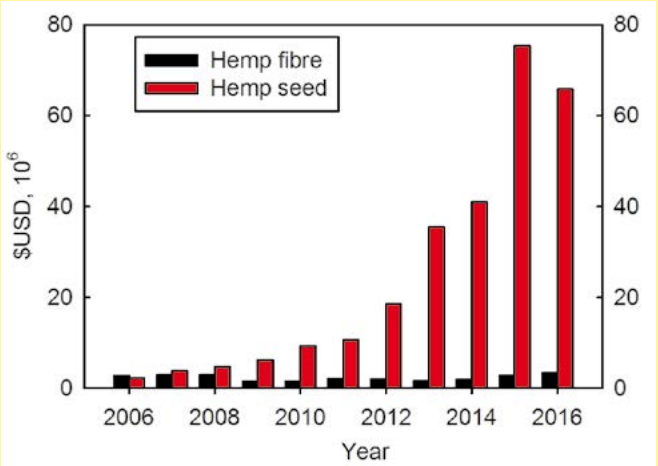
(SOURCE: FAO).

Oilseed

Although hempseed has been used as food for many centuries, oilseed cultivars of hemp have only recently been bred in Europe and Canada. Hulled hempseed has become popular

Hemp has an indeterminate inflorescence and seed shatters easily – hempseed is harvested when about 70 per cent of the seed is ripe.

FIGURE 3: Hemp imports (US dollars) into the US



(SOURCE: US International Trade Commission).

for human consumption, and hempseed imports into the US (primarily from Canada) have increased dramatically in recent years (Figure 3).

Vegetable oil extracted from hemp seeds cannot be used for cooking or frying, and is best used as a fresh salad oil. Because the fatty acids in hempseed oil are mostly unsaturated, it has a relatively short shelf life, and requires dark containers and refrigeration.

Hempseed oil is considered to be a very healthy food, rich in omega-3 and omega-6 fatty acids with an optimum ratio of 3 to 6, and also contains other fatty acids of dietary significance. But oilseed hemp is currently not economically competitive with the other edible vegetable oils. Higher seed yields of the crop are likely through breeding and improved agronomic practices, which would make the crop more competitive.

In North America, hempseed is primarily used as human food, while in Europe the seed is mainly used as livestock feed.

The main concern with hempseed production is yield. Average North American yields of about two tonnes per hectare need to be doubled to compete economically with other oilseeds. Hemp has an indeterminate inflorescence such that individual seeds ripen over time. Also, hempseed starts to shatter relatively soon after ripening. This means hempseed yield is maximised when about 70 per cent of the seed is ripe, with significant seed losses in the field. Improved harvesting technology is required.

Although hemp is considered 'pest-tolerant', birds are one of the exceptions. Birds love hempseed and can be particularly devastating to smaller fields of hemp.

Pharmaceuticals from hemp

Over 100 cannabinoid compounds (terpenophenolics) are found in cannabis, but only a few are present in useable quantities. Cannabinoids are produced in epidermal glandular trichomes (bulbous hairs), mostly in flower parts and on young leaves.

The primary two cannabinoids of interest are tetrahydrocannabinol (THC) and cannabidiol (CBD). THC is the principal intoxicant cannabinoid in marijuana, CBD is the principal non-intoxicant cannabinoid considered to have great medical potential.

Industrial hemp produces mainly CBD, while marijuana biotypes produce mainly THC. The relationship between THC and CBD is antagonistic – CBD reduces the intoxicant effects of THC.

CBD has been used to treat arthritis, cancer, diabetes, neurodegenerative diseases, inflammation, anxiety, and pain. Since oilseed cultivars produce more flowers than fibre cultivars, they are a more promising source of CBD. It may be a feasible strategy to grow conventional oilseed cultivars for a dual crop, collecting both seeds and CBD – but more research is needed.

Potential economic value of CBD has been estimated to exceed that of medical and recreational marijuana combined.

Pharmaceutical companies appear interested in having CBD classified as a prescription medicine, which would greatly restrict or prevent usage in over the counter non-prescription supplements. Several European countries have classified CBD as a prescription medicine only. Currently low doses of CBD are found in dietary supplements in North America. The medicinal legal status of CBD in Canada and the US has yet to be fully resolved.

Hemp microgreens

'Microgreens' is a marketing term that refers to edible greens grown from seeds of vegetables and herbs – typically harvested when they are 7–14 days old. Flavour is more intense and they are considerably more nutrient-dense than mature greens. In age, microgreens are older than 'sprouts' and younger than 'baby greens', and only have a few days of shelf life. Microgreens can be used to garnish soups, salads and sandwiches.

Several individuals in the US have attempted production of hemp microgreens to test the feasibility of this marketing option. Producers need viable hempseed on hand continuously to plant

every few days. Legal issues include the fact that commerce in viable hemp seeds is strictly controlled, and it is considered illegal to be transporting hemp plant parts from one location to another in the US without strict security arrangements.

Hemp microgreens in the vegetable aisle of a supermarket would certainly violate existing security protocols for hemp plant parts in the US. But from a practical standpoint hemp microgreens do not contain a significant quantity of any cannabinoid.

Environmental impact

Hemp is generally pest-tolerant, and has been successfully grown in Canada for 20 years without need for pesticides. On the other hand, a significant white leaf spot disease has been found on hemp in several states in the US after only a couple of years of production. It is not yet clear if this is the same organism in different regions, or if it is the previously identified white leaf spot on hemp, *Phomopsis ganjae*.

Compared to other annual row crops, hemp can have lower environmental impacts, particularly from a pesticide standpoint.

But the fact remains that hemp is an annual row crop that requires relatively high fertiliser inputs and has a relatively high water requirement.

Environmental benefits of hemp commonly found in the popular press tend to be exaggerated.

Hemp has many positive biodiversity features relative to other annual row crops, but it does not compare well with perennial or winter annual forage crops that are often composed of multiple species and usually include N-fixing legumes.

Hemp fibre products are carbon-sequestering and environmentally friendly, but these uses are likely to remain a very small part of the total market.

Hemp with a white leaf spot disease recently found in the US.

Hemp can utilise livestock manure as a fertiliser source and reduce or eliminate commercial fertiliser inputs, but most grain crop farmers will not have a readily available source of animal manure. On the other hand, hemp can be grown organically easier than most other row crops.

Economics of industrial hemp

A number of economic analyses of a potential hemp industry in the US have been conducted over the past 20 years. Studies cited uncertainty about long-term demand and the potential for

oversupply, which are typical concerns for the introduction of any new novel field crop. Lack of a viable processing industry was also cited.

Previous studies were typically focused on hemp fibre and not on hempseed. Hemp fibre requires large, expensive and relatively dedicated processing facilities, while hempseed can utilise existing seed processing facilities with minor adjustments.

A 2017 Kentucky economic study concluded that a hempseed producer could expect a modest profit, while a hemp fibre producer would likely operate at a loss.

There are now hemp decortication plants operating in Manitoba, western Canada, and in North Carolina, US. The North Carolina facility has an 18,000 tonnes per year capacity and is processing both hemp and kenaf fibre. As with any biomass processing operation, there are two primary keys to economic success.

One is the ability to construct and operate a huge processing plant, and the other is to have enough feedstock available to keep the plant running year round. The second point is particularly challenging, as hemp fibre is bulky, and is produced during one short period of the year, and needs to be stored indoors.

The as-yet unanswered question is how much processed hemp fibre is the North American market able/willing to absorb?

It seems likely that it would not take very many processing plants the size of the one in North Carolina to flood the hemp fibre market.

The positive spin on fibre is that there are "as many as 50,000 uses for hemp products" and the market will readily expand to utilise this fibre. The more realistic view is that the hemp fibre market has been relatively stagnant for 20 years, and China would be happy to fill any void with cheap hemp fibre if the need arises.

Politics

Around 300 industrial hemp bills have been proposed in state legislatures across the US to-date. The extraordinary widespread, diverse political support for a novel field crop is unprecedented – and somewhat suspicious. Many legislators proposing hemp laws have no history of interest in field crops.

Hemp legislation has been proposed in states with environments totally unsuited for growing hemp. Very few states conducted any sort of feasibility study to evaluate hemp potential in their state. Much of the 'support' for industrial hemp in the US is really focused on paving the way for legalising recreational marijuana. It is not clear how much support for hemp will remain if and when recreational marijuana is legalised federally.

The American Farm Bureau Federation is one of the largest and most active national farm organisations in the US. In September 2017, Farm Bureau presidents from 27 states signed a letter sent to the US Secretary of Agriculture requesting that industrial hemp be declassified as a Schedule 1 controlled substance, allowing US farmers to engage in legal hemp production.

Although several bills have been proposed in the federal legislature regarding hemp, it is uncertain if and when industrial hemp will be declassified federally in the US.

To sum up

At this point in time hemp has far more potential as an oilseed crop than as a fibre crop. Dietary advantages of hempseed and hempseed oil are quickly gaining acknowledgment in North America. Many companies in North America are currently investing in CBD research, production, processing, and marketing.

It is anticipated that the market for organically-produced hempseed will expand greatly, and relatively local production is usually required to meet organic certification standards.

The oilseed hemp industry is most in need of high-yielding cultivars to increase economic competitiveness – an average productivity of around four tonnes per hectare is required. This is about twice the present productivity of oilseed hemp in North America.

High seed losses (30 per cent) also need to be addressed with improved harvesting technology and breeding to minimise shattering losses.

CBD production has the potential to greatly surpass the combined fibre and oilseed markets, if regulatory agencies take a reasonable approach when addressing CBD.

[1]Professor of Agriculture, Soil and Crop Science Section, School of Integrative Plant Science, Cornell University, Ithaca, NY, US.

Register before Wednesday, December 20, 2017 (www.australianindustrialhempconference.com.au) to save up to $150 with early-bird rates for the Australian Industrial Hemp Conference, to be held in Geelong, Victoria over two full days on February 28 and March 1, 2018. ■

Realising the poo-tential of manure derived fertiliser

Rhys Pirie, Dr Matthew Redding, Dr Wendy Quayle, Shelby Berg and Prof Susanne Schmidt*

AT A GLANCE…

- Concentrated waste streams from Australia's largest intensive animal farms, sewage treatment plants, power stations, meat, sugar and seafood processing plants and municipal waste locations contain the equivalent of approximately 23 per cent, 23 per cent and over 100 per cent of the national agricultural demand for N, P and K respectively.
- Current methods of fertilising with manures result in low nutrient use efficiencies – increasing freight and application costs as well as environmental losses.
- The environmental and social cost of agriculturally derived nitrogen (N) pollution in the US is estimated to be $US157 billion per year which is equivalent to more than 15 per cent of the value of the entire food chain and more than 100 per cent of the value of farmgate production. Per capita, Australian N consumption is 50 per cent higher than the US. The size of this footprint increases dramatically when accounting for the N exported as agricultural produce.
- Australian producers are increasingly under pressure from national and international legislators to reduce losses of nitrogen and phosphorus to avoid water pollution and emissions of the potent greenhouse gas nitrous oxide.
- Research conducted by Deakin University in southern cotton has shown that maximum yield (about 12 bales per hectare in the 2015–16 season) was achieved using a combination of two to four tonnes per hectare of chicken manure and 150 kg per hectare of inorganic N.

THESE days most farmers are aware of the benefits associated with manure-based or organic fertilisers that deliver nutrients coupled to organic carbon, and the increased soil organic matter associated with their use.

The benefit to cotton growers has been identified through trials conducted by Deakin University which confirmed that optimal yield was achieved through a mixture of organic and inorganic fertilisers. Also of interest to cotton growers, given the prevalence of sodic soils in cotton growing regions, is the possible translation of research conducted into subsoil manure application in sodic soils of the high rainfall (>500 mm) wheat growing regions of Victoria.

Over 11 site comparisons between 2005–12, average wheat yield increased 3.6 tonnes per hectare or 63 per cent. Yield increases were attributed to soil aggregation driven by organic matter in the poorly structured sodic subsoil which allowed roots to proliferate deeper in the soil to access additional water and nutrients later in the season.

The amount of nutrients contained in waste streams such as animal manure, sewage sludge (biosolids), sugarcane mill mud and cotton gin trash may surprise some people. As well as containing micronutrients not present in many conventional fertilisers, concentrated waste streams contain large amounts of the macronutrients N, P and K.

Spreading chicken litter using a calibrated commercial spreader prior to cotton bed forming at Whitton, near Griffith, NSW, 2017.

A University of Queensland (UQ) study estimated that the 'waste' generated by Australia's largest intensive animal farms, sewage treatment plants, power stations, meat, sugar and seafood processing plants and municipal waste locations contained the equivalent of approximately 23 per cent, 23 per cent and over 100 per cent of the national agricultural demand for N, P and K respectively. Efficiently utilising this resource would help to reduce Australian agriculture's cost base as well as our reliance on the more than $1.5 billion worth of fertiliser which is imported each year.

But current methods of broadcasting manure tend to rely on the soil improving qualities of organic matter or applying large volumes of material to compensate for their low nutrient content, high water content, low nutrient use efficiency (typically only 10–30 per cent of applied N is taken up by plants) and the difficulty of applying a clumpy material at uniform rates.

The result is freight and application costs which increase quickly, per unit of nutrient, with increasing distance from the source. Improving the use of manure-derived fertilisers, both in terms of transport and formulation is the focus of collaborative research, supported by the CRDC, between The University of Queensland, Deakin University and QLD DPI.

The times they are a-changin'

Nutrient pollution is a well-known, inherent risk of intensive animal agriculture production due to the:

- Large amount of nutrients produced at a single location;
- High cost of freight per unit of nutrient (relatively low nutrient and high water content of manures);
- Low nutrient supply efficiency of nutrients contained in manure when broadcast or spread as slurry;
- Cost and energy requirement of converting manure into higher efficiency fertilisers; and,
- Cost of application methods which minimise nutrient losses through physical and biological processes such as volatilisation and nitrification-denitrification (injection, deep placement).

A chicken litter heap is sampled throughout the profile to ensure all parts of an on-farm pile are represented for nutrient composition analysis.

A recent study from the US (2015) estimated the environmental and social costs of agriculturally derived nitrogen pollution, to which manures have a disproportionally high contribution, at $US157 billion per year which is equivalent to more than 15 per cent of the value of the entire US food chain and more than 100 per cent of the value of farmgate production.

While differences in production systems exist and similar studies are yet to be completed in Australia, we are aware of the need to handle issues like this proactively. The alternative is waiting for direct government intervention – as has already happened in the EU and is a real possibility in Queensland for catchments persistently delivering nutrient rich water into The Great Barrier Reef lagoon.

Opportunities await to repurpose nutrient-rich wastes into superior fertilisers, increase crop production and efficiency of farming, improve soils including carbon levels, facilitate local businesses and reduce dependency on fertiliser imports.

Waste not, want not

Reusing agricultural 'waste' products to provide nutrients to crops is hardly a new concept – manure has been used as fertiliser for at least 8000 years. Yet, in this time our reuse methods have not evolved far beyond the mechanisation of spreading and composting (itself a technique used by the ancient Greeks and Romans).

Far from being second class nutrient sources, manure and organic waste-derived nutrient sources may have an inherent advantage – if only we can learn to use it. Conventional fertiliser additions tend to be in highly soluble forms, promoting losses via a range of paths. This is due to leaching and runoff losses, and in the case of P, the rapid conversion of soluble forms to more stable less soluble forms.

We know that application of fertiliser to accurately match a maturing crop's demand can substantially decrease system losses and inefficiency. We also know that insoluble organic nutrient forms (such as those in manures) tend to be gradually transformed to other forms that can be taken up by plants. Forms that can be taken up by plants include mineral forms (nitrate and ammonia) but also include some organic compounds (amino acids).

This may prove to be a means to re-couple the nutrient and carbon cycles, resulting in less nutrient losses due to nutrient excess. The challenge is to manage or at least predict this transformation and availability process to deliver nutrients "Just in Time" to meet plant requirements.

A range of tools in this regard are either available, or in development. Different technologies currently being tested are:

1. Using sorbents to reduce nutrient loss during storage, processing and application

Ion exchange materials (sorbents) are being studied as a means to tailor nutrient supply to meet plant demand without excessive nutrient availability and associated leaching losses. The advantage of the sorbents in nutrient supply is that these materials tend to maintain nutrient concentrations in solution from a store of nutrient attached to their charged surfaces, supplying further nutrient as the plant takes it up with their roots.

Materials investigated in this role include:

- Hydrotalcite, an anion exchanger able to retain P and N as nitrate; and,
- Bentonite or zeolite which have an affinity for ammonium cations.

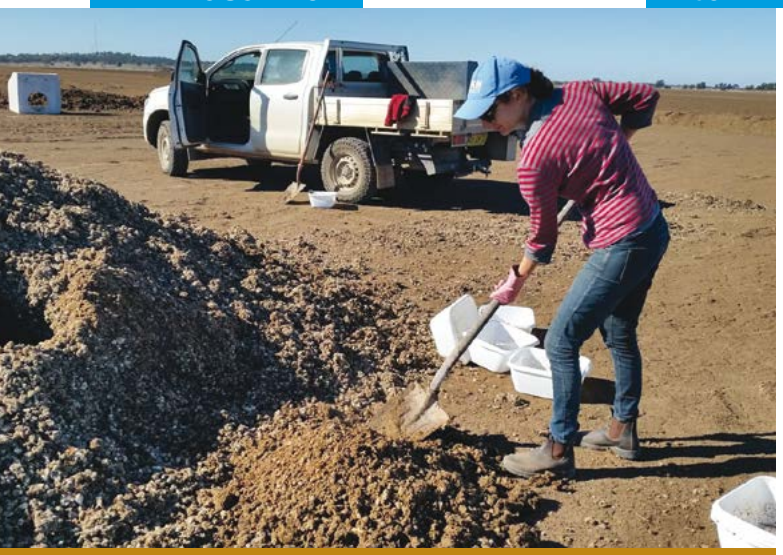
Further studies have established that cation exchanger additions can decrease nitrogen leaching losses, ammonia volatilisation, and even greenhouse gas emissions. Sorbents have also been shown to offset nutrient availability during the season.

The cost of these sorbents, specificity for the nutrient ions in question, and addition of bulk and mass in a fertiliser formulation are the major hurdles to overcome. But direct modification of soil characteristics appears unlikely to be economic, and formulation with the nutrient source under conditions that promote exchangeable retention is the key to success.

Notably, additions of sorbents to manure or organic-waste derived nutrient sources is far more practical than additions to conventional materials. These organic waste-derived materials are already bulky, and the addition of sorbent is less likely to have a major impact on the economically viable transport radius of the product.

2. Transformation controlling compounds eg. nitrification inhibitors

There is also a role for technologies that are able to help control the rate of transformation of nutrient forms from unavailable to available forms. Some of these compounds are



Anika Molesworth, Deakin University PhD student, sampling chicken manure near Griffith, NSW prior to applying to replicated field trials aiming to assess the impact of poultry manure to restore cut areas in laser levelled paddocks.

already seeing application in conventional agriculture (eg. nitrification inhibitors), but these and other compounds may have a role in allowing us to better manage nutrient availability from waste-derived nutrients.

3. Optimising use of manure in Southern Cotton – Deakin University

Utilising manure remains a popular farmer preference in the southern region primarily to maintain soil in good condition to optimize productivity and because of the close proximity to exponentially expanding poultry production sheds. But how to use it to maximize profits is poorly understood. This work seeks to further explain and demonstrate the capability of manure as a fertiliser to meet nutrient targets and to improve profit margins at the rates and types that are practically available as well as how to optimise the resource for the soils of the region.

Commercial scale field trials on transitional red-brown earths have shown that applying two to four tonnes per hectare chicken manure in combination with 150 kg fertiliser N per hectare at sowing attained maximum yields (about 12 bales per hectare in the 2015–16 season) which were slightly higher than using fertiliser alone. Using manure in combination with higher rates (up to 310 kg N per hectare) of chemical fertiliser did not increase yield and decreased nitrogen use efficiency and so profit was lower, although risk was perceived to decrease.

After one year soil mineral N, Colwell P and major cations increased significantly with four tonnes per hectare manure treatments compared with pre-trial baseline soil.

4. Low cost pelletisation and drying methods to reduce the moisture content and increase economic viability of transporting and applying manure

Transport is a large component of the cost of applying manures and water constitutes a large percentage of the cost (40–80 per cent). The around $90 million spent annually in Australia on the transportation and spreading of biosolids (about 80 per cent water) highlights this point.

But when manure is transformed from one large continuous pile to a large number of small discrete spheres (pellets) the surface area exposed to air and, therefore, the ability of air to remove water is greatly increased. Using materials that are also crop inputs we are

Biomass pellets immediately after pelletisation with around 60 per cent moisture content. Pelletisation cost close to $0 net cost when accounting for agronomic value of additives.

Biomass pellets three days after pelletisation with no additional energy used for drying. Less than 20 per cent moisture content.

and offset the processing and drying costs.

The goal is to develop a process where the relative cost of drying/pelletisation is lower than the cost of freight. This would increase the economically viable transport radius and ease of manure application. The net result should be improved farmer returns and decreased environmental losses, while the dry, stackable product would allow for greater flexibility of on-farm storage. While early results are encouraging, significant challenges remain to develop processes viable on a commercial scale.

5. Using Plant Growth Promoting Rhizobacteria (PGPR) and microdialysis to measure and control the release of plant available nutrients from organic material

Microbes control the release of nutrients with each species performing specific functions. Work is currently being conducted to identify, isolate and grow microbes which have beneficial properties such as phosphate solubilisation, nitrogen fixation and plant disease suppression. The next stage is to use microbial innoculants to manipulate the release of nutrients contained in manure derived fertilisers.

The aim of this is to synchronise nutrient release to meet the changing nutrient demands of a growing crop. The measurement of this nutrient release is enabled by microdialysis, a new technique pioneered in agriculture by UQ, which allows for in situ sampling of soil water with minimal disturbance.

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Strange – but true!

By Ian M. Johnston

Having been involved with tractors and earthmoving machinery, for more years than I care to remember, it is not surprising that I have from time to time come across some weird and astonishing bits of ironmongery. In this epistle I have endeavoured to recall some of the more bizarre examples, accompanied with their photos.

1918 Bailor

It was obvious when I climbed on board that this spindly lightweight American tractor had a major design problem. The perilous diminutive seat and the steering wheel were positioned so low, that unless I had a neck of an ostrich, I had absolutely no vision ahead. Plus, the driving chain from the gearbox to the rear wheels was dangerously located a mere inches from my legs. Also, the 12 hp Le Roy four cylinder engine was overly powerful for the slender chassis causing it to flex alarmingly.

1980s Chinese something-or-other

A quick glance at the accompanying photo would suggest you are looking at a John Deere. Nothing is further from the truth! This thinly disguised look-alike was on display at a tractor trade fair held at Sydney's Darling Harbour back in the 1980s. (I forget the exact date). Upon inquiring its make and specifications I was told by a Chinese salesman that an English speaking technician "…would be along shortly." A half hour later I was still waiting. So I inquired from the same gentleman the price, to be informed that he could not divulge this as it would be "by negotiation and anyway payment had to be in US dollars – cash only." Just then an irate security chap came along and complained to my Chinese gentleman that oil pouring from the underside of the tractor was ruining the carpeted floor. I wandered off, having lost interest.

(Please understand that I do not relate this episode to the few excellent Chinese tractors currently available in Australia).

1920 Canadian 14/28

Actually I found the Canadian a surprisingly easy tractor to drive. It was the only tractor ever produced by The Alberta Foundry and Machinery Co of Medicine Hat. What I found especially intriguing with the design was the timber chassis, which could be lengthened or shortened, plus the timber spokes used in the rear wheels! The twin cylinder engine started and ran sweetly, without fuss. My research suggested this was one of two Canadian 14/28 examples remaining.

1972 Cranvel backhoe

Since the early 1950s and into the 1970s, Cranes and Shovels Pty Ltd had made a range of tolerably good tractor mounted front-end-loaders and backhoes (plus a disaster of a four wheel drive four wheel steer loader, powered by a Bedford diesel, named The Crab). But the introduction in 1972 of a "revolutionary new" side shift backhoe indicated that Connor Shea, the respected farm machinery manufacturer, who had recently acquired the Cranvel name, should not have wandered into the complex world of earth moving machinery.

I wasted a day flying down to Melbourne to road test the new Cranvel for a magazine.

The first thing I observed was that the weight of the backhoe was far too heavy for the poor little Fordson Dexta, upon which it was mounted.

Secondly (and here I invite readers to inspect the accompanying photo) I had never sighted such a complexity and

mishmash of hydraulic hoses in all my days. The appearance was as if someone had opened a tin of giant spaghetti and randomly splattered it over the rear of the tractor. (Take a good look). In addition, the ghastly design of the two separate slew mechanisms defied logic, whilst operating the two hydraulic leavers was akin to stirring a plate of porridge!

Very quietly and very soon, the 1972 Cranvel was withdrawn from the market.

1970 Davis Roadrunner

The American Davis Company was a world leader in trench digging machinery. (Although not widely known, the volume selling Massey Ferguson loader backhoes were originally designed by Davis). In the late 1960s, the Australian arm of J. I. Case commenced selling a somewhat radical Davis backhoe, dozer and rear chain digger mounted on a disguised Case tractor.

The only thing was – the backhoe was mounted on the front of the unit! Such an unorthodox design certainly had some obvious advantages, but these were surely outweighed by the fact that the operator was obliged to indulge in major gymnastics, clambering from the backhoe seat to the tractor seat, each time he wished to move the rig along his excavation!

1952 Chaseside loader

This extraordinary British front end loader is mounted on a Fordson Major powered by a Perkins P6 six cylinder diesel engine. Whilst it gives the appearance of a scaffolding and crane gone wrong, this design was not uncommon for the period. All the action was operated by a cable operated by a winch at the rear of the tractor driven by the pto shaft. The operator was obliged to pray that one of the cables did not snap and that all the pulleys were in sound order. This was definitely NOT a loader capable of delicate trimming or precise levelling!

1940s Fowler crane

A close inspection of the accompanying photo will reveal an International WD6 tractor buried beneath all the frame work. Remarkably, a considerable number of these ungainly American conceived units were sold in Australia. Today, a government safety guy would suffer an apoplectic fit if asked to approve the design. In the first place, the operator had had almost nil straight ahead vision (not the sort of thing to impress a safety officer) and to make a left turn it was necessary to turn the steering wheel to the right (wow) and vice versa for a left turn.

Years ago I endured the daunting task of driving a Fowler crane along Sydney's Parramatta Road. (Probably why today I have very little hair on my head). Note the location of the steering cylinders! Driving over anything larger than a golf ball would result in bent rods!

Finally

A tractor scene that will never be replicated! Tractor racing at Sydney's Rosehill Race Course! Yes – true! The photo shows nine tractors lined up in front of the starting gate, awaiting the starter's flag, to send them hurtling along in front of the grand stand – at the same time inevitably chewing up the sacred turf!

How did it happen? This was a promotional stunt engineered by the CEO of Domino Equipment, to promote a new range of Massey Ferguson tractors. Er, were the Rosehill committee members asleep when the request was submitted? ■

IAN'S MYSTERY TRACTOR QUIZ

Question: Can you identify this rugged Australian tractor?

Clue: Take a look at the flywheel.

Degree of difficulty: Easy to a patriotic Aussie tractorman.

Answer: See page 48.

Hot rod technology could help reduce harvester fires

IT seems an unlikely combination – grain growers benefiting from advice provided by hot rod operators in the car racing industry in the interests of reducing harvester fires.

But Ben White an agricultural engineer from the Kondinin Group said the grain industry was now adopting innovation from motor racing specialists when it came to new technology and materials designed to reduce fire risks.

Ben White, agricultural engineer from the Kondinin Group.

Speaking at a GRDC update on Queensland's Darling Downs recently Ben said the move had been fuelled by a driving need to reduce the occurrence and risk of harvester fires.

"It can be quite a contrast when you see a racing specialist arrive in a revved up vehicle to talk with a grain grower about modifying their harvester with gear found in the race car pits," he said.

"But the simple reality is we share a common goal – to get to the finish line without our machinery suffering a catastrophic thermal event."

He said things like heat shield paints, or fire retardant fibrous coatings, exhaust bandages or jackets and insulative double ceramic skins on the exhaust system were just some of the racing industry's thermal barrier options now being trialled on grain harvesters.

"It is important growers check first whether modifications like these will impact their warranties, but they are just some of the tools coming into play to help us reduce the risk of harvester fires."

Ben said harvester fires could damage equipment, destroy crop and infrastructure and endanger lives.

"Larger plantings of pulse crops in recent years, driven by favourable pricing has further elevated the risk," he explained.

"Research by the late Dr Graham Quick indicates winter pulse crops are up to five times more fire prone than wheat during harvest."

Australian growers largely on their own

Ben said Australian growers were largely 'on their own' in a sense, in terms of harvesting in conditions conducive to fires, which meant international harvester manufacturers were less likely to specifically alter vehicle design or materials in response to the needs of Australian growers.

"But while we are trialling and evaluating some of those technologies and materials from the racing sector, there are practical things growers can do during harvest to reduce their fire risk this season."

"But there are a number of elements that add to the risk of fire on harvesting machinery. Most of these can be monitored, maintained, addressed and ultimately fire risk can be significantly reduced."

He said the Kondinin Group had conducted research which found the major causes for approximately 50 per cent of fires on harvesters were:

- Dust and trash build-up on the machine; and,
- Bearing failures.

Mechanical failures are also implicated in one in 12 harvester fires.

Reducing the fire risk

To reduce the risk of harvester fires this year Ben recommends:

- Regularly cleaning down machinery to reduce fuel load;
- Monitoring bearings with an infrared temperature gun;
- Monitor ambient conditions and the fire danger index;
- Consider heat shield or exhaust modifications, such as:
  - Exhaust paints, or coatings including ceramics and alumina silica which can minimise dust adhesion and reduce hot component surface temperatures;
  - Exhaust bandages and blankets which are designed to insulate exhaust components; and,
  - Double skins on the exhaust system (which are insulative, like a thermos);
- Ensure an electrical isolator system is used;
- Ensure fuel system is well maintained;
- Maintain and keep airflow systems clear;
- Check concave doors are well sealed (minimise dust leakage which may in turn contact hot surfaces);
- Ensure your harvest team has a plan and knows their individual responsibilities in the event of a fire; and,
- If your harvester does catch fire pull out of the paddock and call 000.

"We know there is definitely more research work to be done to minimise harvester fires including what influences crop ignition temperatures, understanding harvester heat signatures and how best to insulate the components above ignition temperatures," Ben said.

"Which is why this work with the motor racing industry has been so interesting and is really relevant to the grains sector."

For more information go to the GRDC Grain Harvester Fires Back Pocket Guide: https://grdc.com.au/ ■


Agricultural engineer Ben White said the grains industry was learning from the car racing sector when it came to new technology, materials and design to reduce the fire risk when machinery was operating at high temperatures.
(PHOTO: Katrina White)

Caution urged with pre-harvest herbicide applications

GRAIN growers are being encouraged to exercise caution and good stewardship when undertaking pre-harvest application of herbicides in this year's winter crops.

Growers applying herbicides late in the season to manage weeds, prevent weeds setting seed or to desiccate crops to accelerate or even-up ripening must adhere to herbicide label recommendations and withholding periods to avoid the presence of chemical residues in delivered cereal, pulse and oilseed grains.

To support growers and their advisers in ensuring late season herbicide application is carried out in a responsible manner, the Grains Research and Development Corporation (GRDC) has published a revised *Pre-Harvest Herbicide Use* Fact Sheet.

Know your limits

The Fact Sheet emphasises the importance of knowing the maximum residue limits (MRLs) of domestic and international markets and outlines the product registrations for pre-harvest weed control and desiccation which vary according to crop type.

GRDC Senior Manager Crop Protection, Ken Young, says application of herbicides close to harvest increases the possibility of detectable herbicide residues being present in harvested grain.

"In some situations, markets have extremely low or even zero tolerance to some herbicide and pesticide residues.

"It is therefore critical that growers know the destination of their grain and that particular market's MRLs to determine which, if any, herbicides are permitted for use on their crop late in the season," Ken said.

"MRLs vary according to herbicide, crop and market, and compliance with Australian MRLs does not guarantee the grain will meet an importing country's MRL.

"Breaches of MRLs can lead to rejected grain, so growers should seek advice from their grain buyers before they undertake late application of herbicides."

Ken said growers and their advisers need to be aware of the implications of applying herbicides to crops in terms of food health safety and in protecting the entire grains industry.

"Stewardship must be taken seriously by all sections of the grains value chain, and that responsibility starts on-farm."

Grain handlers and marketers regularly conduct surveillance on grain receivals for residues. The National Residue Survey also conducts ongoing residue testing of grain.

The Pre-Harvest Herbicide Use Fact Sheet can be viewed and downloaded via the GRDC website at https://grdc.com.au/GRDC-FS-PreHarvestHerbicide. ■

LOW GLYPHOSATE EXPOSURE FROM EATING TREATED CROPS

A US study has looked at glyphosate levels in humans in the situation where the herbicide Roundup is sprayed onto genetically modified food crops or applied as a desiccant pre-harvest to non-genetically modified grains.

From 1993 to 2016, a University of California study of elderly adults in California has found that they've had increased exposure to the pesticide glyphosate, with higher levels found in their urine over time.

This coincides with an increased use of glyphosate in the area since 1994, and indicates that people can be affected without direct contact just by eating the products – none of the study participants were farmers.

But while the glyphosate levels did increase, they were still much lower than those from previous studies of non-farmer European adults, and more than 50 times smaller than a dose thought of as 'ultra-low' that was consistently fed to animals and resulted in liver inflammation.

Environmental exposure through dietary intake of these crops has potential adverse health effects and can be assessed by measuring urinary excretion, 2-4. The US study measured excretion levels of glyphosate and its metabolite aminomethylphosphonic acid (AMPA) in participants from the Rancho Bernardo Study (RBS) of Healthy Aging.

Source: Scimex Newsfeed.

Application of herbicides close to harvest increases the possibility of detectable herbicide residues being present in harvested grain. (PHOTO: GRDC)

WEED smart
every weed every seed
every farm every year

ASK AN EXPERT – HOW DOES MIXING HERBICIDE MODES OF ACTION BUY MORE SHOTS?

With Rick Rundell-Gordon, Senior Agronomist, Grounded Agronomy

ROTATING herbicide modes of action 'buys you time', but mixing 'buys you shots'. When a herbicide is released on the market it has a fairly predictable number of uses or 'shots' before resistance to that mode of action begins to be evident in the weed population. For example, in-field experience and computer modelling both show that repeated use of glyphosate on a weed population will evolve full-blown glyphosate resistance in approximately 15 years. This effective lifespan ranges from around four years to over 20 years for the most commonly used herbicides, before resistance is evident.

Rick Rundell-Gordon, consultant agronomist with Grounded Agronomy, Swan Hill, says the widely-promoted and well-adopted practice of rotating between herbicide modes of action has the beneficial effect of 'buying time' because if a MOA is used once every two years the lifespan of the herbicide effectively doubles.

"This means the herbicide remains a viable option for weed control for longer and the more diversity in herbicide MOAs applied, the longer the effective use is for all the herbicides in the program," he says. "If a nil-tolerance approach is taken to weeds that survive a herbicide application then herbicide resistance is much less likely to evolve."

"We now know that mixing two or more compatible herbicides with different modes of action can also increase the number of times an individual herbicide can be used within the herbicide program," says Rick. "Mixing works by targeting different mutations within the weed population with the one spray application."

For example, mixing trifluralin with another pre-emergent herbicide, both at full label rates, can increase the number of 'shots' of both herbicides across the cropping rotation. An important proviso is that the weed population must still have some susceptibility to all of the tank mix partners.

'Mix and rotate MOA' is so important it is one of the Big 6 WeedSmart strategies to manage herbicide resistance.

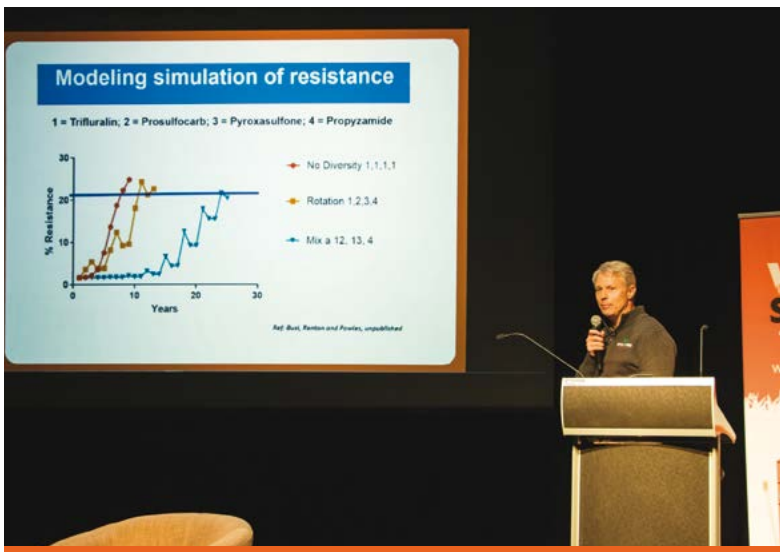
What evidence is there that mixing herbicide MOAs is effective in delaying resistance?

Short answer: Glyphosate resistance in waterhemp in the US was less likely to occur when farmers used tank mixes.

Longer answer: Researchers from the University of Illinois, the USDA-ARS Global Change and Photosynthesis Research Unit, and the State University, New Mexico used spray records from a local spray contractor to compare 50 fields with glyphosate resistant waterhemp and 50 fields without. They looked at a total of 61 management and environmental variables and found that mixing herbicides was the single management strategy that made the most difference to whether or not glyphosate resistant waterhemp became a problem in any field.

In a review of herbicide application records from 2004 to 2006 and glyphosate resistance tests in 2010, the researchers found that adding more products to the tank at full rates for a single application causes the probability of resistance in these fields to decline sharply.

Peter Newman, AHRI says the evidence is mounting that 'mixing and rotating herbicide MOAs buys you time and shots'.



Rick Rundell-Gordon, Grounded Agronomy speaking at WeedSmart Week 2017 in Wagga Wagga about the science behind the 'mix and rotate' tactic to target multiple resistance mutations in weed populations.

Is there any research to suggest that mixing pre-emergent herbicides could be effective?

Short answer: Computer modelling has demonstrated that the onset of herbicide resistance can be delayed when a mix and rotate strategy is used with pre-emergent herbicides to control annual ryegrass.

Longer answer: Based on research from the Australian Herbicide Resistance Initiative, the best advice to growers and agronomists is to rotate between these three groups of pre-emergent herbicides:

- Trifluralin;
- Sakura, Boxer Gold and triallate; and,
- Propyzamide.

Full label rates must be applied.

Assuming four herbicides available (trifluralin, prosulfocarb, pyroxasulfone and propyzamide) AHRI researcher Dr Roberto Busi has also simulated three different scenarios:

- Use the same herbicide continuously (trifluralin or any other herbicide if the crop rotation permits);
- Follow a simple herbicide rotation pattern; or,
- Mix and rotate using two herbicides in each mix.

The results show that mixtures are more effective than just rotating MOA in delaying resistance as mixes generally achieve a greater kill rate.

Is mixing and rotating herbicides all I need to do?

Short answer: No. Mixing and rotating herbicide modes of action can effectively lengthen the life of a herbicide MOA on your farm but it will not prevent resistance on its own.

Longer answer: In addition to carefully selecting and managing herbicides it is necessary to also implement as many cultural (non-herbicide) tactics into your weed control program as possible. The overall aim of a sustainable weed management program is to use as many tactics as possible to keep weed numbers low, prevent weed seed set and remove all survivors. ■

HOW TO ASK A WEEDSMART QUESTION

Ask your questions about the affect of soil pH on weed management on the WeedSmart Innovations Facebook page WeedSmartAU, Twitter @WeedSmartAU or the WeedSmart website http://www.weedsmart.org.au/category/ask-a-weedsmart-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.

When mixing herbicide modes of action, always use full label rates and ensure all products are compatible.

Sowthistle – know the enemy, exploit its weakness

Going into the 1932–33 Ashes tour in Australia, Don Bradman was averaging around 100, and he had averaged 139 in the 1930 tour of England. He seemed unbeatable. How then, did he go on to only average a paltry 56.57 in the 1932–33 Ashes? Simple, the English cricket team had discovered his weakness, short, fast, leg side bowling known as bodyline, and they employed this tactic much to the chagrin of the Australian public. "It's just not cricket!"

WHEN we are faced with a new enemy, that is seemingly unbeatable, we need to investigate its weaknesses and then perhaps we can see a way to exploit these weaknesses – just as the English cricket team did in 1932.

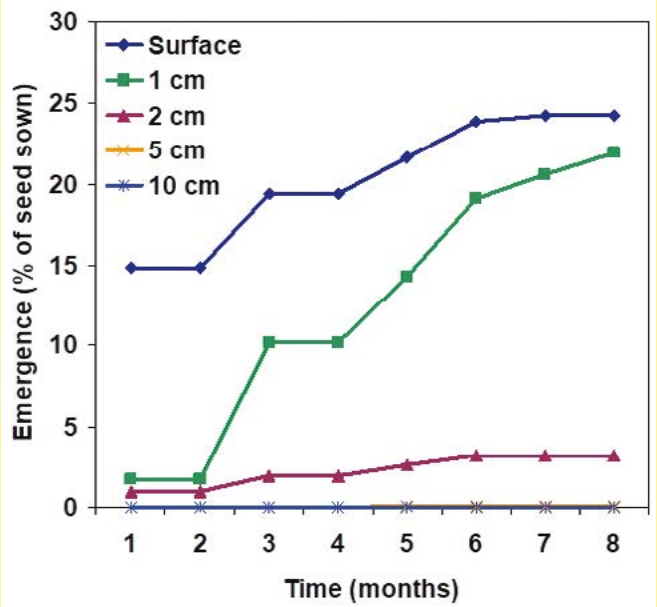
Common sowthistle in north-eastern Australia, for example, appears unbeatable. It can germinate all year round, with a single plant producing up to 25,000 wind-dispersed seeds. Many of these seeds are able to germinate straight away (having no dormancy), glyphosate resistance is now becoming very common, and our no-till farming system has played right into its hands leaving most seed on the soil surface from where it can germinate.

What a nightmare! Surely this weed is unstoppable.

But if we take a look at its weaknesses, we can perhaps see some options. Research by Michael Widderick from QDAF tells us that its seed is short lived (as little as eight months), seeds can't germinate from a depth of two cm or more, and it hates competition from the crop.

Sure, glyphosate resistance makes life hard, but if we think a little like Douglas Jardine, the English cricket captain in 1932, perhaps we can see a way forward. To learn a little more about the biology of sowthistle and how we might beat this weed in the long term, read on.

FIGURE 1: Sowthistle seed germination characteristics



- All year round germination;
- Majority from top 1 cm;
- None below 2 cm;and,
- None after 8 months.

The enemy

Common sowthistle (*Sonchus oleraceus*) also known as milk thistle, was rated the fifth most difficult weed to control in winter crops in the northern grain region of Australia and is widespread throughout Queensland and northern NSW.

Germinates all year round

Sowthistle will happily germinate at any time of the year if there is adequate moisture making management challenging as plants are present throughout much, if not all, of the year. It can be common in both summer and winter crops and fallows, with multiple generations within a year.

Glyphosate resistance is now common

Glyphosate resistance was confirmed during a 2014–15 survey of the northern region (Annie van der Meulen, QDAF). In this survey, 123 populations of sowthistle were tested. Out of these

Michael Widderick tells us that sowthistle seed is short lived (as little as eight months), seeds can't germinate from a depth of two cm or more, and it hates competition from the crop.


YOUNG SOWTHISTLE


SOWTHISTLE UP CLOSE


SOWTHISTLE AFTER HARVEST

populations, 34 were either resistant or developing resistance to glyphosate. While there was a higher incidence of resistant populations in northern NSW (Liverpool Plains), one population from central Queensland was also confirmed as resistant.

Exploit the weaknesses

Righto, so what are some of the weaknesses of sowthistle that we may be able to exploit?

Surface germinator

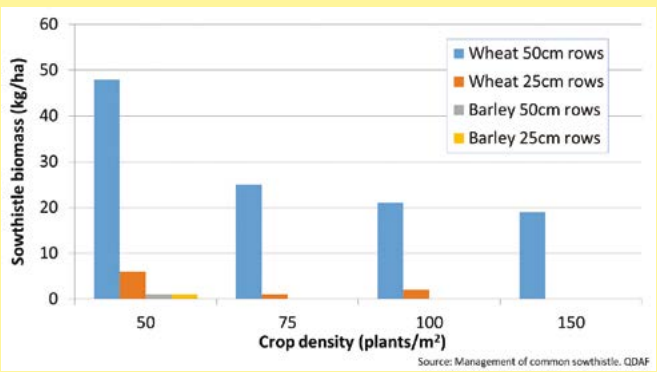
One of sowthistle's ecological weaknesses is its much reduced germination if seed is buried deeper than two cm in the soil (Figure 1). Germination is favoured when seeds are on or close to the soil surface with no emergence from a depth of two cm or greater (Michael Widderick, QDAF).

But, if buried deep, the seed can persist

While seed burial can reduce emergence, seed burial can also increase seed persistence. Sowthistle seed buried below a depth of two cm can persist and remain viable for longer than seeds that are in the top two cms of soil.

A study in Queensland found after 30 months of burial, 12 per cent of sowthistle seed buried at 5 or 10 cm, remained viable compared with less than one per cent when seed was buried at 1 cm depth.

FIGURE 2: Sowthistle biomass and crop competition



In short, if you plan to cultivate to bury sowthistle seeds, they must be left buried for at least three or four years before any more cultivation.

All surface seed is gone in eight months

In the absence of seed bank replenishment, studies by Michael Widderick, QDAF, have shown that sowthistle germination from surface lying seed will cease after approximately eight months. This is good news as it tells us if we can keep a paddock weed free for a year or so, and the majority of weed seeds are on or near the surface, we can smash the sowthistle seed bank.

Sowthistle hates competition

Cultural weed control practices to increase crop competition such as reducing row spacing and increasing crop density are effective. The data in Figure 2 shows how much sowthistle hates competition. This research was conducted in the absence of selective herbicides for sowthistle. This effect is common across a range of weed species with some suffering more than others at the hands of a competitive crop.

Certainly, using herbicides in combination with crop competition will reduce weed density and seed production in crop and lower the weed seed bank in your soils. This will result in a lower sowthistle pressure in fallows, where non-chemical options are limited.

To sum up

Sowthistle has become a very common weed in summer and winter fallows and crop and resistance to glyphosate is making management difficult. To defeat an opponent, we need to exploit their weakness, and in the case of sowthistle it appears that two of the key weaknesses are its ability to compete with the crop, and the ability to emerge from greater than two cm.

Add to this the short seed life and we are starting to understand what a bodyline series against sowthistle might look like.

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NORTHERN FOCUS
COVERING NORTHERN NSW AND QUEENSLAND

Managing the Rutherglen bug burden

RUTHERGLEN bug (RGB) has been an increasingly frequent and very problematic pest for grain growers in Queensland and New South Wales over the past 10 years, but recently observed behaviours are causing further concerns.

Senior entomologist with the Department of Agriculture and Fisheries (DAF) in Queensland, Dr Melina Miles said over the past four years agronomists have observed that large numbers of RGB – which breed in canola crops – have caused damage to establishing summer crops.

This type of damage is in addition to the significant yield losses that can be attributed to RGB adults in sorghum and sunflowers during grain fill.

"Our observation of this damage in seedling summer crops is relatively new," Melina said.

"To date very little research has been focused on the phenomenon of RGB movement from canola stubble to damage an establishing summer crop.

"DAF entomologists have done some preliminary work, which has provided some insight, but there needs to be further research in this area."

RGB nymphs at all developmental stages and adults typically move en masse from canola stubble as it dries down in October-November, with the movement occurring in all directions. Melina said it appears to be an exodus rather than direct movement towards summer crops.

"In southern Australia, the same movement occurs and is of little consequence as there are no summer crops," she said.

"In contrast to summer cropping regions further north, in central NSW, the benefit that RGB provide by feeding on and killing canola regrowth, volunteers and weeds is appreciated by growers as a plus.

"But where RGB are moving into summer crop, they will

Melina said over the past four years agronomists have observed that large numbers of RGB, which breed in canola in winter–spring have caused damage to establishing summer crops. (PHOTO: Keith Power)

congregate on seedlings and the sheer impact of feeding results in plant dehydration and death.

"Repeated spraying of crop edges slows the movement of the RGB further into the summer crop, but does not prevent the death of plants in rows closest to the canola. The movement from the canola stubble can continue for weeks."

Entomologist Melina Miles says new research will help better explain how to manage the Rutherglen bug burden.

This number of RGB moving makes barrier strips, ploughed strips and water-filled channels ineffective in stopping the movement. The absence of effective, long residual products that can be applied to bare earth between canola stubble and summer crops is a major constraint in having a simple management option.

Three key strategies

"The three key approaches we are researching this year, include preventing the build-up of RGB, effective barriers to the movement from stubble to summer crop and reducing RGB populations in summer crop," Melina said.

Until 2007, RGB was not considered a major pest of sorghum although it has been recognised as a major pest of sunflowers for a long time. But we saw extremely high populations in 2007 causing damage and in 2016–17, RGB populations were also extremely high and persisted in crops for weeks.

"Control proved very difficult, prompting questions about efficacy and possible resistance, so DAF entomologists have undertaken screenings and further research was undertaken," Melina said.

"Findings showed that while all registered products were effective when directly contacting adult RGB, in the field when RGB populations are large it is unlikely that commercial application will get good direct contact on all individuals. This means the residual efficacy of the insecticides becomes important.

"What is clear from these results is that the residual efficacy of the treatments varies, with rapid deterioration of synthetic pyrethroids after three days, in contrast to the longer persistence of the organophosphates."

For more tips from entomologist Melina Miles on how to identify and manage RGB check out this GRDC Know More video at https://youtu.be/BnGDHhNmdIE ■

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More money from mungbeans with nitrogen

NEW trial data is confirming that nitrogen can improve the performance of mungbean crops for growers seeking to maximise yields and returns.

The surprising results come from Incitec Pivot Fertilisers' long-term nutrition experiment at 'Colonsay' in southern Queensland and suggest that nitrogen fixation from inoculation may not be adequate or reliable, especially in late planted crops.

Lead researcher for the site, Bede O'Mara from Incitec Pivot Fertilisers, presented the results to growers at a recent field day.

He suggested that growers consider applying up to 80 kg per hectare of nitrogen pre-plant to ensure that the fast-growing crop has access to enough nitrogen to reach its yield potential.

The trial compared three rates of nitrogen applied mid-winter last year to the rhizobia inoculated mungbean crop sown on January 1, 2017 and harvested on May 1, 2017.

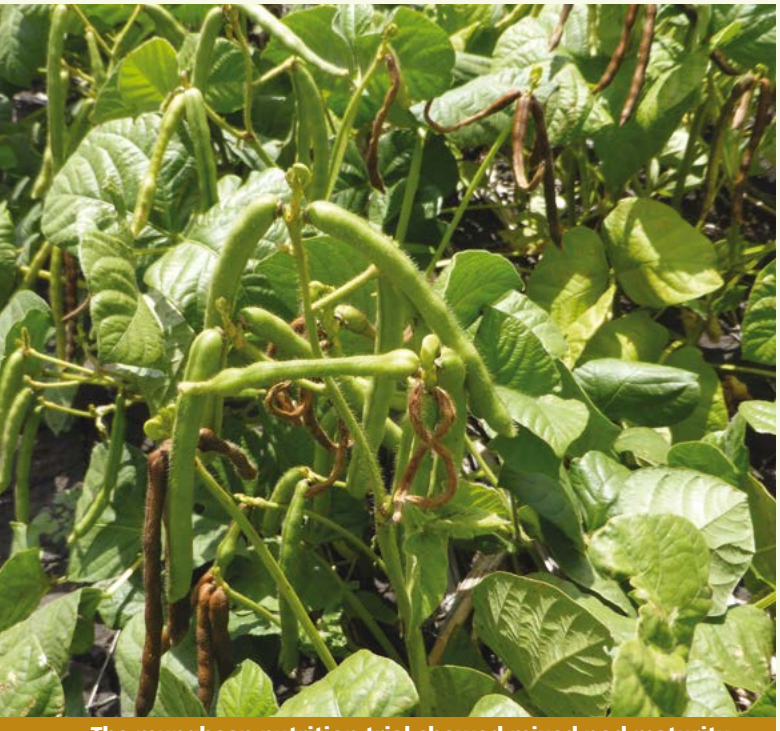
Mean grain yields jumped by significant margins with increases in nitrogen fertiliser, starting from 1.52 tonnes per hectare where no nitrogen fertiliser was added.

Highest return from 80 kg N

The crop yielded 1.85 tonnes per hectare where 40 kg per hectare of nitrogen was applied and 2.14 tonnes per hectare where 80 kg per hectare of nitrogen was applied.

Bede said the highest returns net of fertiliser cost were achieved at this 80 kg per hectare of nitrogen rate, calculated to be $1714 per hectare.

Returns were calculated based on urea delivered bulk on farm for $0.97 per kg of nitrogen, triple superphosphate delivered bulk on farm for $2.71 per kg of phosphorous and a gross receival price of $900 per tonne for mungbeans.



The mungbean nutrition trial showed mixed pod maturity and damage following the rain from TC Debbie – as did many other crops in the region this year.

Bede O'Mara, sub-tropical farming systems agronomist, Incitec Pivot Fertilisers, is encouraging growers to use nitrogen to improve mungbean yields.

"This was despite up to 20 per cent of the harvested grain being graded out and the remainder achieving the lower manufacturing grade, largely due to weather damage from extreme heat and from downpours caused by ex-tropical cyclone Debbie," he said. "Sadly, this was also the case for many commercial crops in 2017."

The highest mean grain yield of 2.2 tonnes per hectare was achieved when 120 kg per hectare of nitrogen was applied.

With the possibility of prices remaining high for good quality mungbeans, Bede said northern growers were turning over thousands of hectares to the crop, making it the pillar crop in many summer grain rotations.

"Growers have every reason to invest in the success of their mungbean crops by supplying the nitrogen required to optimise yield in a good season and achieve the best possible returns," he said.

Test for deep soil nitrogen

Bede said deep soil nitrogen testing can help determine whether a pre-plant nitrogen application is needed to support mungbean crop growth and yields.

The mungbeans in the trial had access to some nitrogen from background soil supplies, with estimated starting soil nitrogen levels ranging from 26 kg to more than 300 kg per hectare of nitrogen.

"This was only revealed by soil testing well in advance of planting," he said.

"Nitrogen deficiency symptoms in the nil treatments were only visually obvious at or after budding, which is too late for in-crop nitrogen applications to be effective."

Based on the trial data, he said that 250 kg per hectare or more of total soil and fertiliser-supplied nitrogen may be required to maximise yields in favourable seasons.

"The only problem for growers today is that any nitrogen applied to paddocks right now or at planting will need additional

rainfall and more time than we have to move down into the root zone where it can be best utilised by the crop," he said.

"For this season, growers may have the opportunity to make a late switch to mungbeans in paddocks originally set up with pre-plant nitrogen for other summer crops, if it is likely to provide a better return on the nitrogen investment."

Bede said post-harvest grain testing was conducted as part of the experiment.

"Grain tests showed nitrogen removal exceeded supply, even where 80 kg per hectare of nitrogen was applied," he said.

"The 80 kg per hectare of nitrogen treatment removed 113 kg per hectare of nitrogen, which equates to 45.5 kg of nitrogen for every tonne of grain harvested.

"We would ordinarily expect significant amounts of nitrogen to be fixed by a healthy inoculated mungbean crop, but the rhizobia may have slowed in function or died when exposed to the high temperatures. If this happened, the crop wouldn't have fixed any or much nitrogen."

The crop was planted late due to a dry spring and early summer.

Minimising urea losses

In other results from the experiment, Entec urea showed some potential for improving yields.

Entec urea is used to stabilise ammonium in the soil, preventing the rapid conversion of ammonium to nitrate nitrogen.

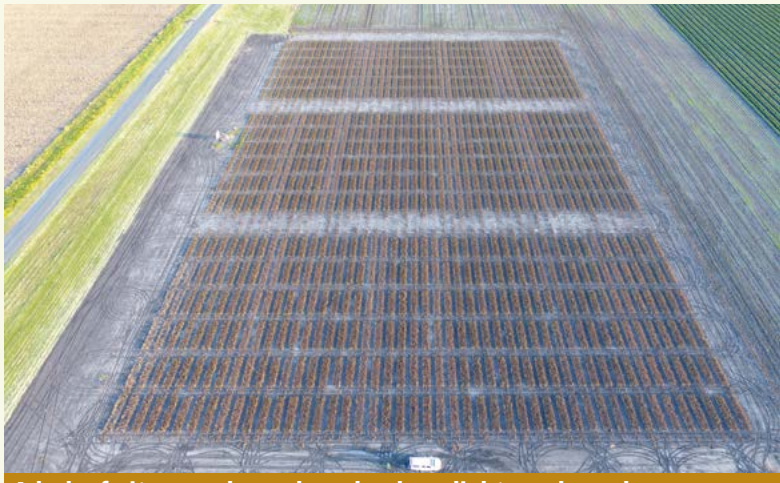
"This helps to minimise the potential for losses following application through leaching and denitrification, and we certainly experienced some wetter periods through late winter and early spring in 2016 after the pre-plant applications," Bede explained.

"It looks like using Entec urea may have allowed more of the nitrogen applied to be retained in the soil and available to the crop, as it significantly increased yields in the 40 kg per hectare of nitrogen treatment compared with untreated urea."

The comparison of urea with Entec urea has been a sub-treatment within the long-term experiment since 2013, providing short and long-term information about the effects of the enhanced efficiency fertiliser.

Incitec Pivot Fertilisers intends to further research efficient nitrogen management strategies.

In the meantime, Bede is encouraging growers to consider giving their mungbean crops a flying start this season with an improved soil supply of nitrogen. ■



A lack of nitrogen showed up clearly as lighter coloured plots in this aerial shot of the Colonsay trial site, taken on April 21, 2017.

Sorghum Farming Has Gone Viral!

It's been a few years since we have seen a solid start to a summer season across the northern grain belt. These good conditions often cause a rapid build-up of *Helicoverpa armigera* numbers, and flowering sorghum will be one of the most attractive crops this December leading up to Christmas.

Vivus® Max (*Helicoverpa* NPV) is established as the proven standard for *Helicoverpa* management in sorghum. The real value of NPV lies in its ability to replicate in the field, giving increasingly better control over time, allowing the virus to control caterpillars during flowering and right-through to harvest.

Go early...

With this understanding of the biology of NPV, many consultants and farmers know that the best way to use Vivus Max in sorghum is to apply it during early flowering. With chemistry, the old approach was wait and target as many larvae as possible with one spray, which caused damage along the way, disrupted beneficials, and risked the need for a clean-up spray for late tillers or pressure. Using NPV early sets-up the natural virus cycle and eliminates the risk of significant losses from *Helicoverpa* damage with a single, cost-effective application.

... keep costs low ...

For farmers with ground rigs, Vivus Max can be effectively applied in bands to keep costs low. For

Don't hang around, use Vivus Max early.

An early Vivus Max spray paying off.

aerial application, AgBiTech has registered a low water volume recommendation (with Optimol®) to reduce application costs. Early use of Vivus Max is also compatible with other approaches, such as lower application rates (Vivus Max is registered at 75 to 150 mL per hectare in sorghum) and double swathing, to help further reduce the cost of managing *Helicoverpa* in sorghum.

Using a low cost Vivus Max strategy and based on $200 per tonne sorghum prices, *Helicoverpa* thresholds are generally below 0.5 larvae per sorghum head.

... to minimise risk and maximise profitability!

These recommendations are all geared toward encouraging the early application of Vivus Max. Experience has shown that large acreages of flowering sorghum around Christmas can cause significant challenges for farmers and operators being able to apply Vivus Max on-time, especially if there is some rain about. Taking the low-cost, pre-emptive approach avoids delayed sprays, and reduces tillering for maximum earliness, meaning more grain is delivered into the early market and moisture is conserved for the next crop.

For further information, contact AgBiTech:

Ph. 1800 242 519 Web: www.agbitech.com Twitter: @agbitech

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A new niche market mungbean

By Cindy Benjamin

THE Australian Mungbean Association is proud to commercialise the latest variety released from the National Mungbean Improvement Program – a new black gram variety named 'Onyx-AU'.

Black gram (*Vigna mungo*) is a close relative to green mungbean (*Vigna radiata*) but with a black seed coat and white kernel. It has distinctly different biology, production and markets to green mungbean. Until now, Regur has been the only black gram variety available for Australian growers to access this niche market in Australia and overseas.

AMA president Mark Schmidt said Onyx-AU will help expand and grow the export market of Australian mungbeans. "Filling the premium markets and having supply 12 months of the year is our first goal – after this we would look to compete in the massive Indian market," he said. "Onyx-AU will not compete with its green mungbean counterparts in the market place."

Onyx-AU is a direct replacement for Regur, which was released to industry in 1975, and is the first black gram variety developed through the National Mungbean Improvement Program (NMIP). Onyx-AU joins a line of successful releases from the NMIP, a co-investment of the Queensland Department of Agriculture and Fisheries (DAF) and the GRDC.

Potential as a specialty pulse

At the official release of the new black gram variety during the first week of November, Dr Rex Williams, DAF's Director of Crop Improvement spoke enthusiastically about the potential of the new black gram variety to help develop a small but important market.

"Most people are now familiar with the high quality green mungbeans grown in Australia and with the release of Onyx-AU there is scope for black gram production to steadily grow and capture some of the premium global market for this specialty pulse," he said.

DAF's senior plant breeder Col Douglas and AMA president Mark Schmidt inspect the new black gram variety, Onyx-AU at a trial site near Kingaroy.

Chris Murphy, GRDC Business Development and Commercialisation manager (north) said the NMIP was a very successful plant breeding program that has been running since 2003, having provided a high return on investment, with a cost-benefit ratio of around 12 to 1.

"GRDC and DAF have been long term co-investors in the NMIP, along with the AMA as the commercial partner, and we welcome the recent contributions of the Queensland University or Technology and the University of Southern Queensland to the future development of mungbean varieties with improved yield and disease resistance," he said.

DAF's senior plant breeder, Col Douglas said Onyx-AU had performed well in a limited number of trials in southern Queensland where it has been, on average, 11 per cent higher yielding than Regur.

"Onyx-AU is well-suited to the same areas where Regur has been produced successfully on the Darling Downs, northern New South Wales and Liverpool Plains," he said. "It has not yet been evaluated in Central Queensland."

Not easy to grow

Black gram is generally considered more difficult to grow than green mungbean. Onyx-AU is a similar plant type and requires similar management to Regur, and is recommended to experienced black gram growers.

It flowers and sets pods from lower in the canopy so the selection of level and uniform paddocks is an even greater consideration than for green mungbean. Recognition of crop growth stages and effective scouting and management of insect pests demands more care than in the production of green mungbean. Onyx-AU reaction to halo blight is superior to current large green-seeded mungbean varieties, such as Crystal and Jade-AU.

Black gram is a specialty market and consultation with the marketer is recommended before making the decision to plant. There is some scope for larger volumes to satisfy the growing demand for Australian-produced black gram due to its superior quality compared to product from other countries.

Like all the current varieties of green mungbean, Onyx-AU is also protected under the Plant Breeder's Rights (PBR) legislation. Growers can only retain seed from their production of Onyx-AU for their own use.

A seed royalty, which includes breeder royalties, applies at the point of sale. This royalty contributes directly to the NMIP and is re-invested in research to develop future mungbean varieties.

Australian Mungbean Association (AMA) seed committee convenor, Geoff Birch said the $270,000 royalty cheque recently presented to DAF and the GRDC was testimony to the effectiveness of the NMIP, which has so far delivered five new mungbean varieties to meet the needs of the industry.

Geoff said there are good supplies of the main green mungbean varieties Jade-AU, Crystal, Satin-II and Celera II-AU available to growers for the 2017–18 season and encouraged growers to arrange their seed, fertiliser and crop protection products early.

More information: www.mungbean.org.au ■

SOUTHERN AUSTRALIA FOCUS

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

Check canola pods on the branches, not just the stem

By Cindy Benjamin

CANOLA seed colour change indicates peak yield and oil content, making it the key determinant for timing windrowing or desiccation. While most growers and agronomists are aware of this key indicator, there are some misconceptions about what constitutes seed colour change and how it should be assessed.

South Australian consultant Trent Potter, Yeruga Crop Research, said that growers must stay in control of the timing for windrowing and desiccation, and need to know how to assess the maturity of the seed themselves.

"Adverse weather events such as a very dry finish or frost, can result in low yields, low oil content and increased levels of green seed as the seeds are killed before they are fully mature.

With around 70 per cent of canola yield coming from pods on the side branches, growers are encouraged to assess seed colour change in all pods before windrowing to maximise yield and oil content while minimising the amount of green seed at harvest.

Unfortunately, there is nothing growers can do about that," he said. "But under favourable conditions the correct timing of windrowing or desiccation will mean growers maximise the yield and the oil content and also avoid any penalty for green seed."

Trent said it is imperative that growers open the pods and check the seed colour themselves. "A visual estimation based on pod colour is not sufficient and will result in lost profits if not quality downgrades," he said.

When to windrow?

The timing of windrowing has been the subject of significant research effort co-funded by the GRDC, NSW Department of Primary Industries, CSIRO and partner organisations under the Optimised Canola Profitability project (CSP00187).

Researchers have re-confirmed studies from the 1970s and 80s that showed physiological maturity in canola is reached when 40–60 per cent of seeds on the main (primary) stem change colour from green to red, brown or black. But their research has also shown the importance of assessing seed colour change on the canola plant branches as around 70 per cent of the crop yield is held on the plant branches rather than the main stem.

Rick Graham, NSW DPI, Tamworth said windrow timing studies in 2015 and 2016 at Tamworth and Trangie, and Edgerio in 2016, clearly demonstrated the importance of correct timing.

"There was less than a week between too early and optimal timing," he said. "In five days the seed colour change on the primary stem increased from 18 per cent to 61 per cent."

There is a significant delay in physiological maturity between seed in pods on the stem and pods on the branches, and this needs to be included in the grower's assessment.

"For the seed in pods on the branches to reach 40 per cent seed colour change, the seed on the stem pods are likely to be as high as 60 to 80 per cent changed," Rick said. "For growers to maximise yield and oil content, and avoid rejection due to green seed, we recommend collecting pods from both stems and branches and assessing the overall seed colour change, rather than relying only on the maturity of the pods held on the main stem. Overall the seed colour change should still be 40–60 per cent red, brown or black seed collected from both the stem and the branches."

Green seeds discolour the oil

Nick Goddard, Australian Oilseeds Federation CEO said that an incorrect visual image of 'Green Seed' in the GTA Visual Reference Standard Guide (VRSG) for last season saw consignments of canola accepted on delivery with too much green seed present.

"Green seed contains chlorophyll, which discolours the canola oil, adding to the cost of processing," he said. "The standard for green seed has not changed. There is no penalty for green seed up to a maximum of two per cent green seed, assessed visually. Grain can also be assessed using a laboratory test for chlorophyll where a maximum content of 12 ppm is acceptable."

"This season what is classified as a green seed in the VRSG has been clarified and tightened and we are reminding growers that grain colour will be assessed against the visual standard published in this year's VRSG."

Nick said the Visual Reference Standard Guide is available on the Grain Trade Australia (GTA) website.

Australian Oilseeds Federation: www.australianoilseeds.com

For further information contact Nick Goddard, Executive Director of the Australian Oilseeds Federation, 02 8007 7553.

Time to think about lime requirements

LIME use in Western Australian agricultural systems dropped 25 per cent this year and grain growers are encouraged to carefully assess their lime requirements ahead of the 2018 cropping season.

Soil acidity is estimated to erode potential grain crop yields by up to 13 per cent, worth $500 million annually. The issue is widespread, affecting about 11 million hectares in WA – about half of the state's grainbelt.

Department of Primary Industries and Regional Development (DPIRD) researcher Chris Gazey said a combination of factors saw lime sales fall to 1.2 million tonnes (mt) prior to the 2017 cropping season, compared with about 1.6 mt for each of the two previous years.

"Reasons included financial constraints caused by low grain prices and frost damage to crops, and a wet summer which saw growers busy spraying weeds and some paddocks made inaccessible for lime trucks," he said.

Higher yielding paddocks that only require maintenance liming should be prioritised for lime application, to ensure they do not become more acidic and start losing production.
(PHOTO: Evan Collis Photography)

"The 2017 growing season has also been very challenging for many growers, but in many cases, investing in a liming program to manage soil acidity will still be achievable and profitable."

Chris leads a five-year project looking at new soil amendment options and tillage tactics for soil acidity, in partnership with the University of Western Australia, as part of the GRDC *Investments in Soil Constraints – West*.

He said the specific lime requirements for different paddocks could be determined by soil testing, with accurate knowledge of the soil pH allowing more precise management decisions.

Soil pH is a measure of the concentration of hydrogen ions (acid) dissolved in the soil water.

Know the pH in soil layers

"Growers need to know the degree of soil acidity and its depth, and to know the soil pH profile in layers of at least one to 10 cm, 10 to 20 cm and 20 to 30 cm," he said.

"Topsoil pH can be quite different from the subsurface soil pH and sampling only the topsoil may lead to inadequate lime applications."

Chris said subsurface acidity had deepened in many WA cropping soils and recommended growers already sampling at depth should consider obtaining some samples from 30 to 40 cm and, in some cases, 40 to 50 cm.

He said growers developing a liming plan should consider which paddocks required lime, based on soil testing, and prioritise paddocks.

"Higher yielding paddocks that only require maintenance liming should be prioritised for lime application, to ensure they do not become more acidic and start losing production," Chris said.

"Usually the most acidic paddocks also have a range of other subsoil constraints and they probably should not be the ones you tackle first, unless you have already addressed the other issues present.

"When applying lime to paddocks with multiple constraints or when there is soil acidity at depth, using some form of tillage can help to move the lime further down into the profile, removing compaction at the same time."

The GRDC western region 'Know More' video Tips to manage subsoil acidity with liming can be viewed at https://grdc.com.au/r/soilacidity

More information on soil acidity is available at https://www.agric.wa.gov.au/ ■

DPIRD researcher Chris Gazey says overall lime use in WA fell by 400,000 tonnes last year. (PHOTO: GRDC)

Time operations to give snails the slip this harvest

GROWERS are advised they can minimise the chances of snail contamination of grain by adjusting the timing of their harvesting operations.

Department of Primary Industries and Regional Development (DPIRD) entomologist Svetlana Micic said small pointed (conical) snails (*Prietocella barbara* (L.)), which were the most common snail variety in Western Australia, were more likely than other species to be found intact in harvested grain.

Svetlana, who leads snail research in WA as part of a national Grains Research and Development Corporation (GRDC) investment, said snail contamination could lead to grain being rejected at receival points, requiring grain to be cleaned.

"Two types of snails may be found in paddocks in some areas of WA – small pointed snails and round snails (white Italian and vineyard snails)," she said.

"Harvester modifications are more effective on round rather than small pointed snails and it is important to identify snail species to make appropriate management decisions."

Svetlana said round snails were easily dislodged from grain whereas small pointed snails could be found in sheltered locations such as between the leaf and stem and were not easily dislodged from crops by the harvester.

"But growers can reduce the risk of contamination by adjusting the timing of harvest in high-risk paddocks," Svetlana said.

"As temperatures increase, round snails are more likely to climb up onto crops whereas small pointed snails are more likely to seek shelter where it is cooler, including underneath stubble.

"Harvesting at the hottest time of the day will decrease contamination from small pointed snails.

DPIRD entomologist Svetlana Micic says snails are more likely to descend to the ground when temperatures are cooler, especially after rain. (PHOTO: GRDC)

Snails are more likely to be present in harvested grain if numbers are above 20 per square metre in cereals and five per square metre in pulses and canola. (PHOTO: GRDC)

"But under cooler conditions, round snails are more likely to climb down from crops whereas small pointed snails are more active and have been observed moving over crops.

"Harvesting at night or during cool days increases the risk of contamination from small pointed snails but decreases the risk of contamination from round snails."

Snails are more likely to be present in harvested grain if numbers are above 20 per square metre in cereals and five per square metre in pulses and canola.

Svetlana said small pointed snails had been found to move into windrows (swaths) of crops, such as canola.

"Consider harvesting windrow crops as soon as practicable, as the longer a swath is on the ground the more small pointed snails may be found harbouring under or in the swath and can be incidentally harvested," she said.

"Also consider swath height, as swaths that are close to or on the ground tend to have more small pointed snails in the grain."

Svetlana said cleaning grain after harvest could remove snails.

She advised growers to inspect machinery and to clean equipment where necessary before it entered their properties.

More information about snail management is available at https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia and https://www.agric.wa.gov.au/mycrop/diagnosing-snails-crops

Information especially relevant for the management of round snails at harvest time is available in the GRDC Snail Management Fact Sheet at https://grdc.com.au/GRDC-FS-SnailManagement

The GRDC snail and slug investment is led nationally by the South Australian Research and Development Institute (SARDI) and aims to expand ecological and biological knowledge of snails and slugs to provide growers with regionally-specific information for effective timing of controls.

In WA, the focus is the grainbelt's two most problematic species – small pointed (conical) snails and black keeled slugs – and trial sites are in the Great Southern and south-east coastal regions. ■

Seed testing and dressings are key smut strategies

BARLEY growers concerned that high levels of loose smut will be carried over into next year's crops are encouraged to test retained seed for the disease following this harvest and to use seed dressings prior to sowing barley in 2018.

WA Department of Primary Industries and Regional Development (DPIRD) researcher Andrea Hills said barley growers, particularly in medium to high rainfall areas, experienced high levels of barley loose smut (*Ustilago nuda*) this year.

She said all varieties could be affected but growers of Hindmarsh, and its sister line, La Trobe, were more likely to be impacted by the disease, which reduces grain yield and affects export opportunities for some markets.

Andrea, who conducts DPIRD research into loose smut as part of a Grains Research and Development Corporation (GRDC) crop disease investment, urged growers who were concerned about smut levels to assess them in spring each year.

"In most cases, levels of the disease are actually much lower than they appear," she said.

"The disease can in most cases be profitably managed, so growers should not be unnecessarily alarmed.

"Having said this, as seed infection occurs during flowering, the long, cool spring in 2016 may have led to higher than usual infection rates of seeds used to sow 2017 barley crops."

Andrea said good growing conditions in a number of southern areas of WA in 2017 meant more infected seed survived to produce smutted heads.

"This year's spring has been relatively favourable for loose smut transmission and renewed infection in many barley growing areas, so smut levels might be high again next year," she said.

Andrea said testing seed retained at harvest would give growers a better idea of what they might face if they did not treat it carefully with a premium seed dressing.

Loose smut in Hindmarsh barley. (PHOTO: Andrea Hills, DPIRD)

Close-up image of loose smut in Baudin barley during a past season at Avondale Agriculture Research Station. (PHOTO: DPIRD)

The results of product efficacy trials are available at *https://www.agric.wa.gov.au/barley/controlling-barley-loose-smut-2015*

"If seed is tested and found to be at or higher than the five per cent infection level, growers may benefit from replacing it with a new batch of seed – for example from the lower rainfall area which usually has lower levels of smut," she said.

Andrea said to keep smut under control, growers should use seed dressings every year and application was critical, with every seed needing a dose.

"It is worth noting we cannot prevent seed from becoming infected with loose smut, and seed dressings can only control the smut that is already present in the grain," she said.

"Also, no seed dressing can be expected to give 100 per cent control, even with perfect application.

"But treating seed is still worthwhile and stops the problem from escalating."

Andrea said all seed dressings reduced loose smut, but in 2013 DPIRD trials some premium products controlled it at the 99 per cent level.

"But at a paddock scale, even with 99.9 per cent control and perfect application, at a 70 kg per hectare sowing rate of 'average' La Trobe sized seed that has a one per cent level of infection, there will still be 1.4 infected plants for every 30 by 30 metre square," Andrea said.

More information about barley loose smut management is available by searching the DPIRD website https://www.dpird.wa.gov.au

Growers wishing to test seed can contact DPIRD Diagnostic Laboratory Services (previously AGWEST Plant Laboratories) on 08 9368 3351 or ddls@agric.wa.gov.au ■

Matricaria on the move

THE bright yellow flowers of matricaria are in full bloom and Western Australian growers are urged to report sightings of this foul smelling weed to determine how far it has spread.

The weed is very difficult to control in pasture once it takes hold and spreads quickly thanks to a very large seed bank that can remain viable for five years.

Research officer Alex Douglas, from the WA Department of Primary Industries and Regional Development (DPIRD), is studying the biology and control options for matricaria as a part of a five-year project supported by Grains Research and Development Corporation (GRDC) on locally important weeds, including stinking lovegrass, Feathertop Rhodes grass and mallow.

Alex says matricaria has been reported in areas including Southern Cross, Mukinbudin, Merredin, Kellerberrin and Beacon and there has also been a population found near Esperance.

"We are keen to determine just how widespread matricaria is, and while it is flowering is the perfect time to look out for it," she said.

The bright yellow flowers of matricaria are in full bloom.
(PHOTO: Kylie Chambers, DPIRD)

"Landholders are encouraged to report any populations of matricaria, especially outside of known areas."

Alex said the initial management trials were focused on seed set control options for the pasture phase as an aid to reducing the seed bank. Laboratory and glasshouse research will complement the field work.

"Control options are limited while the plant is flowering, but farmers can note where it was found and be prepared to control it next year when the small plants emerge," she said.

Timing of spray is critical

Preliminary results from field trials (Merredin and Mukinbudin) are showing that time of application of herbicides is critical.

"Selective herbicides need to be applied to small plants to be most effective and knockdown applications may work best when mixed with other herbicides, to act as a 'spike'," Alex said.

"The best time for applications targeting seed set is likely to be before plants are fully flowering.

"While most matricaria plants die off in early summer after flowering, a few plants may germinate in late winter and continue to grow and produce seed over the summer period, providing conditions are favourable.

"This is becoming more common as the eastern grainbelt experiences more seasons with increased summer rainfall."

There are two species of matricaria in WA and they can be distinguished by their flower heads. Columba daisy (*Oncosiphon suffruticosum*) has more 'club' shaped flower heads while Globe chamomile (*Oncosiphon piluliferum*) has rounder, globe shaped flower heads.

Both varieties of matricaria are annual herbs with bright yellow flowers. They have a strong smell and form dense stands.

Sightings may be reported directly to Alex Douglas on alex.douglas@dpird.wa.gov.au or 0455 067 755, or via the Pestfax Reporter app which is available for Apple and Android.

More information can be found at https://www.agric.wa.gov.au/diseases/pestfax-reporter
http://www.rcsn.net.au/uploads/5/4/2/8/54288593/adouglas-all.pdf

A combined WA distribution map for Columba daisy and Globe chamomile is available at https://florabase.dpaw.wa.gov.au/browse/map/22708 ■

Good news for lupin growers

LOCAL lupin crops have been given the all clear for lupin anthracnose disease after a joint NSW Department of Primary Industries (DPI) and Local Land Services biosecurity surveillance operation found no sign of the devastating disease in NSW.

NSW DPI pulse pathologist, Kurt Lindbeck, said lupin anthracnose was first detected in NSW commercial crops in October 2016.

"Surveys across the state have been part of an ongoing plan to eradicate the disease in NSW," Kurt said

"NSW DPI provided diagnostic and technical support to the surveillance operation, which involved five Local Land Services areas – North West, Central West, Riverina, South East and Murray.

"With strong support from lupin growers, agronomists and local communities we will continue to work towards eradication of the disease into the next year."

A total of 38 LLS and seven NSW DPI staff took part in the operation, which inspected 92 albus and narrowleaf lupin crops, and covered 9800 hectares.

In 2016, six farms in the Cootamundra-Gundagai, Coolamon and Junee shires were confirmed to have anthracnose.

The infection was isolated and controlled, and an eradication plan was put in place.

Cootamundra-Gundagai, Coolamon and Junee shires remain subject to restricted conditions under a biosecurity zone to control lupin anthracnose.

Residents of these three shires are not permitted to grow ornamental lupin plants to help support the eradication campaign.

Additional restrictions have been placed on properties where anthracnose was found, and properties whose boundaries were within one kilometre of an infected property.

Surveillance for lupin anthracnose will be conducted in spring 2018 to confirm absence of the disease and support an eradication declaration for NSW. ■

Kurt Lindbeck and Michael Leane conducting lupin anthracnose surveillance.

Surveillance of 92 albus and narrow leaf lupin crops throughout NSW in the 2017 growing season has found no sign of anthracnose disease.

Increased investment in Centre for Crop and Disease Management

A $100 million national research centre will receive an $18 million funding extension over three years to build on research that has reduced the economic impact of crop disease for Australian growers.

Supported by Curtin University and the Grains Research and Development Corporation (GRDC), the Centre for Crop and Disease Management (CCDM) was the result of the first bilateral research agreement between the GRDC and an Australian university.

The GRDC will invest $6 million per year to at least 2022, enabling the Centre to continue its national research excellence in fungicide resistance, molecular genetics and farming systems.

CCDM Co-Director (agronomy and agribusiness) Professor Mark Gibberd said this was excellent news for the Centre and a testament to the research discoveries made by CCDM researchers since it was established three years ago, in 2014.

Research making a difference

"It has been fantastic seeing our hard work make a difference over the past three years," Mark said.

"For instance, we have rapidly detected many cases of fungicide resistance and provided real-time advice on the efficacy of fungicide chemistry, while at the same time developing field-based evidence for anti-resistance strategies.

"We have received incredible support from industry on a national scale, including disease sample collection support, field trial and lab experiment collaboration and joint coordination of forums and workshops."

CCDM Co-Director (scientific programs) Professor Karam Singh said the continuing significant investment from Curtin University and GRDC will enhance the impact of science discoveries as CCDM researchers developed the genetic tools needed to breed disease resistant varieties.

"Over the past three years, we have gained more insight into the interaction between fungal pathogens and their cereal host plants," Karam said.

"With this knowledge, we have been able to unravel aspects of the pathogens' arsenal for infection and this has helped speed up the breeding process for disease resistance.

This research, along with new outcomes from our pulse and canola disease resistance programs, has meant CCDM is well placed to contribute research to the development of crops with increased disease tolerance or resistance for growers."

GRDC Chairman John Woods said the CCDM investment extension was evidence of the successful way in which the bilateral agreement had improved the efficiency of the delivery of research outputs for the benefit of Australian grain growers.

"By investing in research, such as the work carried out at the CCDM, we can help address the $1.5 billion crop disease problem faced by Australian grain growers every year, and ensure growers and advisers receive important management information so they can make necessary changes at the paddock level.

"As a result of the CCDM investment, Australian growers are saving millions of dollars, making this value-for-money investment in the CCDM vital to the profitability of the nation's agricultural industry," John said.

"The GRDC and Curtin University partnership in the CCDM has demonstrated how, with appropriate resourcing, targeted focus and world class expertise we can deliver outcomes to address some of the most difficult and costly issues for growers. That's why GRDC is pleased to continue this partnership with Curtin University to 2022." ■

Russia keeps 'Putin' up wheat production

By Peter McMeekin, Nidera Australia Pty Ltd (a member of the COFCO International Group)

ANOTHER lacklustre week on global grain markets concluded with a bearish jolt when the USDA released their November World Agricultural Supply and Demand Estimates (WADSE) on November 10 (Australian time).

The market bulls would have certainly felt a little squirmish reading the report, especially with the corn numbers. The USDA surprised the market with a 3.6 bushel per acre (bu/ac) month-on-month increase in the national corn yield to 175.4 bu/ac. This equates to 4.46 tonnes per hectare.

If achieved, this would be a record US yield, bettering the previous benchmark by 0.8 bu/ac. Even more notable is the fact that none of the top 10 corn-producing states are forecast to achieve record yields.

According to the USDA, the biggest driver is the second highest average ear weight on record, last year being the highest.

With a bigger US crop comes a bigger export task and a larger US carry out. US corn futures retreated as a consequence, setting a new low for the December contract. Not good news for the US or South American farmer, both of which are said to be undersold compared to long-term averages.

Soybeans favoured in South America

On the soybean front, the USDA left yield unchanged at 49.5 bu/ac (1.35 tonnes per hectare) against an average trade estimate of 49.3 bu/ac. The big mover in soybean production was South America. Brazil's soybean production is forecast at 108 million tonnes (mt), up 1 per cent compared to October but still 5 per cent below last year's record.

The area planted to soybeans across all Brazilian states is forecast to increase again this season, at the expense of first crop corn. This continues a long-term trend and is a reflection of the disappointing financial returns for corn compared to soybeans.

The new crop plantings may only be 75 per cent complete but this does mean that a favourable season could still see last year's production record broken.

Plenty of wheat around... again

The wheat news was quite benign with the USDA pushing the global production estimate up marginally to 752 mt – only a freckle below last year's record of 753.9 mt. It also confirmed another 1.0 mt increase in the Russian wheat crop to a record 83 mt. This is the net weight, as opposed to the delivered weight,

Peter McMeekin, Origination Manager, Nidera Australia (a member of the COFCO International Group).

with the big variable being the cleaning and drying losses post delivery. These are typically 4 to 5 per cent of the delivered weight which is reported at 87 mt.

The Russian wheat crop reportedly yielded an average of 3.06 tonnes per hectare – up more than 14 per cent on last year's record. According to the Russian Ministry of Agriculture, outstanding yields were achieved in Siberia, a region that accounts for nearly half of the country's spring wheat production.

Black Sea wheat stocks rising

The bottom line here is that global wheat stocks (primarily in the Black Sea region) continue to climb while US wheat stocks are shrinking. This makes the export task for the US and many other major exporters quite difficult as the huge Russian crop continues to weigh on the global wheat market.

This was borne out when the lineup (results) for the most recent Egyptian General Authority for Supply Commodities (GASC) tender was released. There were 14 Free on Board (FOB) prices submitted – all were Black Sea port exporters, and 11 of them were Russian.

Australian production and exports

Meanwhile, the USDA is calling the current Australian wheat crop at 21.5 mt. This is unchanged month-on-month and is probably on the high side of domestic trade expectations. The early spring rainfall certainly arrested production decline in some regions, but it also came too late to save the crop in others.

The other interesting estimate from the USDA was 19 mt of wheat exports – down 1.0 mt from the October estimate. Admittedly, this is for the July 2017 to June 2018 period and more than 5 mt has already been shipped.

Nonetheless, It does mean that Australia will need to export a solid 1.7 mt every month for the next eight months on the back of much lower year-on-year production.

Whilst this is not impossible, it does mean that we will need to capture some elastic demand over that period. With Black Sea wheat landing into Asian demand points at around US$20 under Aussie values at the moment, at least one of three things will need to occur:

- Domestic basis decreases;
- Black Sea values increase; or,
- The Aussie dollar falls out of bed.

Among the barley...

GLOBAL barley markets have been quite subdued and uneventful in recent weeks and appear to be in search of news that will set the tone as we enter the northern hemisphere winter.

Saudi Arabia is the world's largest importer of barley but is forecast to reduce imports to around 8.0 mt in 2017–18. This will be down from more than 9.0 mt in the previous season.

Substituting barley with corn

The Saudi Arabian Grain Organisation (SAGO), which has exclusive buying rights for feed barley, have indicated that they were looking to partially substitute domestic feed barley consumption with imported corn due to the uncompetitive price of barley relative to corn and other stockfeed ration alternatives.

The opportunities for corn in Saudi Arabia are huge. Their dairy industry is state of the art by world standards and the poultry industry is expanding rapidly, supplying both the domestic market and into neighbouring Gulf countries.

One of the biggest suppliers of feed barley into Saudi Arabia is Ukraine. Interestingly, the Ukraine farmer has been swinging spring barley area across to corn in recent years. New varieties and vastly improved farming practices in Ukraine have significantly increased the profitability of corn relative to barley.

Whilst the global corn market is extremely competitive, Ukraine will be extremely well positioned to increase their exports as Saudi Arabia increases imports. Currently, the world's fourth-largest exporter of corn, further increases in production and exports could easily see Ukraine challenging for a place on the podium in the not too distant future.

Lower Australian barley exports

In reality, much lower barley production here in Australia this season, compared to last, and relatively strong domestic demand means that the exportable surplus will be much lower year-on-year. Australia will not have to chase export demand aggressively this season.

Relatively inelastic demand out of other Gulf states such as the United Arab Emirates, Kuwait and Oman will be preferred over the competitive Saudi Arabian demand. But China will be the key market for Australian feed barley.

In addition, international wires are reporting that the Black Sea region is close to sold out of barley and the winter export focus will turn to wheat and corn. This effectively takes one of the world's biggest barley supply regions out of the market ahead of the Australian harvest.

So what will drive Australian barley values as harvest progress ramps up across the country? As we know, sustained dry spells across the growing season have led to domestic supply deficits in some regions along the east coast and surpluses in others. The movement of grain to balance that supply and demand equation will be a key driver of eastern Australian values into the New Year.

In the traditional export zones of Western Australia and South Australia, growing tightness in global supply will most likely be the key influence. Traditional export demand and trade flows will be the driver rather than burdensome supply needing to find a home before the next northern hemisphere harvest. ■

Australian feed barley on the menu in Asia

By Australian Export Grains Innovation Centre

ASIAN chickens could soon be getting a higher proportion of delicious and nutritious Australian barley as part of their diets.

AEGIC CEO Richard Simonaitis said newly-developed technical information on the characteristics of Australian feed barley was being received with interest by customers in Asia.

"We identified an opportunity to increase awareness of Australia as a reliable producer of high quality, clean feed barley by providing information to customers about its nutritional benefits as well as technical information about how to incorporate it into feed diets," Richard said.

"The demand for feed grain in Asian markets is strong and growing stronger. As a result, Australia's competitors are already very active in the marketplace, which is why this type of work is very important."

The value of Australian barley

AEGIC engaged poultry nutrition specialist Dr Tim Walker to prepare technical information to help customers understand the value of using Australian barley.

Tim has already presented the information at conferences in Indonesia and Vietnam, with plans for several more international presentations in the coming months.

Tim said Australian barley was suitable as feed for all classes of poultry.

"Australian feed barley is very low in mycotoxin contamination, which is a key selling point for Asian customers," he said.

"It has good nutritional attributes and energy content; and has higher fibre than some other feed grains, which can be beneficial for gut development and function." ■

FAST FACTS...

- Australia produces about 6 million tonnes of feed barley annually.
- Around 4.2 million tonnes of feed barley is exported each year (though these figures vary from season to season).
- Australia makes up around 5 per cent of the world's total barley global production (feed and malting).
- Approximately 60 per cent of Australia's total barley crop (feed and malting) is exported annually.
- China is Australia's largest barley market, worth almost $1 billion. Malting barley for beer production is a key driver in China.
- There may be opportunities to grow exports of Australian feed barley to China and other Asian countries as demand continues to grow.

Real value of stockfeed

FARMERS who made hay from this season's failed crops are finding variations in feed quality, as tests reveal the value of their fodder. NSW DPI Feed Quality Service (FQS) analytical chemist, Richard Meyer, said variable nutrition levels in 2017 canola hay and silage samples confirmed the importance of testing fodder.

"Protein levels varied from a low 6.8 per cent to a very high 23.9 per cent, and metabolisable energy ranged from 8.2 to 10.6 megajoules per kilogram," Richard said.

"Variable quality is common in failed canola crops – feed quality declines as plants mature and delayed harvest dates should alert farmers to test fodder.

"Nutrition levels are influenced by the leaf-to-stem ratio – in general, higher leaf and pod content delivers higher protein and energy values."

Canola nitrate levels should be tested to manage toxicity risks to animals – some samples had levels over 5000 milligrams per kilogram and care should be taken in feeding stock.

Fodder to fill the gap

NSW DPI sheep production research officer, Edward Clayton, said producers with insufficient pasture or forage crops will need to fill feed gaps with fodder reserves this season.

"Failed cereal and canola crops can be a valuable resource in filling the gap," Edward said. "Most importantly, producers who are feeding stock need to know the nutritional value of their feed to ensure they can meet the nutritional needs of livestock.

"We advise farmers to seek out an accredited feed quality laboratory, especially if they intend to purchase fodder."

Based at the Wagga Wagga Agricultural Institute, FQS has an 'A' rating from the Australian Fodder Industry Association Fodder Testing Proficiency Program and is accredited by NATA.

FQS, the only facility in Australia which integrates research and commercial feed testing, delivers seasonal ranges and average values for fodder and measurements of protein, metabolisable energy, fibre content and water soluble carbohydrate levels.

Additional testing services include nitrate levels, mineral content, prussic acid and mould counts. The service tests all feed types.

Feed sampling kits are available on order from NSW DPI's website. ■

DPI analytical chemist, Richard Meyer and technical assistant, Anna Richards, prepare hay, silage and grain samples for testing.

Thirty years of Helicoverpa research in inland Australia

PART 1 – THE INSECTS AND THEIR HOSTS

By Peter Gregg, University of New England

AROUND the world, semi-arid regions with unpredictable rainfall are outbreak areas for certain insect pests. The locusts and armyworms of Africa are classic examples, as are our own Australian Plague Locusts. These insects are highly polyphagous (they can utilise many plant species) and highly migratory. They have short life cycles and lay many eggs, meaning they can reproduce very quickly. Ecologists call this set of characteristics the *r*-strategy, and it works by enabling insects to colonise areas that have recently become favourable – where their population growth is largely free of constraints from natural enemies.

Many agricultural pests are *r*-strategists, and in the 1980s a group of entomologists realised that Helicoverpa (then the number one enemy of conventional cotton) fitted the model. The Helicoverpa Inland Research Group (HIRG) was formed by researchers from the University of New England, CSIRO, Queensland DPI and the University of Queensland, and for seven years we studied the distribution and abundance of Helicoverpa in a broad region of inland Australia, with funding from CRDC, GRDC and RIRDC.

When that work ended, a project funded by the Australian Research Council involving researchers from UNE and the Australian Defence Force Academy in Canberra investigated the potential of radar for monitoring insect migration from the inland. Then in 2000, CRDC funded a project to test our capacity for forecasting migration.

From 2001 to 2008 there was no work in the inland. Two important things happened during this break. One was the Millenium Drought – the worst recorded drought in southeast Australia – which drastically reduced production. The other was the introduction of Bollgard II GM cotton crop varieties, which basically removed Helicoverpa from the pest management equation – so long as they remained susceptible to Bt toxins.

In 2009 another CRDC-funded project investigated whether alleles (segments of DNA that code for protein) for Bt resistance existed in inland *H. punctigera* populations, far from the summer cropping region.

They do, but at much lower frequencies than in the summer crop region.

This made Helicoverpa migration from the inland an opportunity rather than a threat, because it might bring in susceptible insects to genetically dilute Bt resistance.

But there was evidence from other research – notably from a CSIRO pheromone trap network in the lower Namoi – that we were seeing less immigration from the inland. So we examined the ecology of Helicoverpa in the inland.

In all, we have made 79 field trips to the inland. While the researchers and the objectives of the projects have varied, certain techniques (pheromone trapping, sweep netting for larvae, and host plant assessments) have remained constant, and this has allowed us to build up a picture of the long-term ecology of Helicoverpa which is almost unique in world entomology.

In this article we will focus on the larval sampling, and what we have learned about the native host plants.

Host plants

We made a total of 2053 sweep net samples on 233 hosts (mostly natives) from 32 plant families. For *H. punctigera* we

FIGURE 1: Densities of *H. punctigera* larvae on inland hosts, 1987–2017

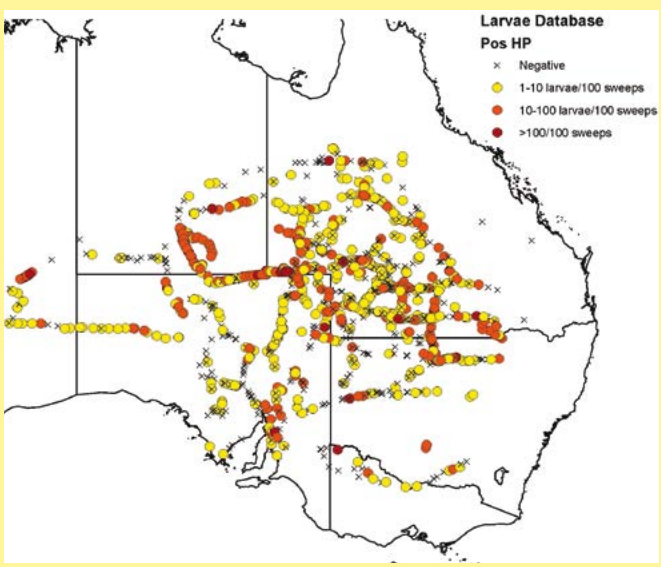
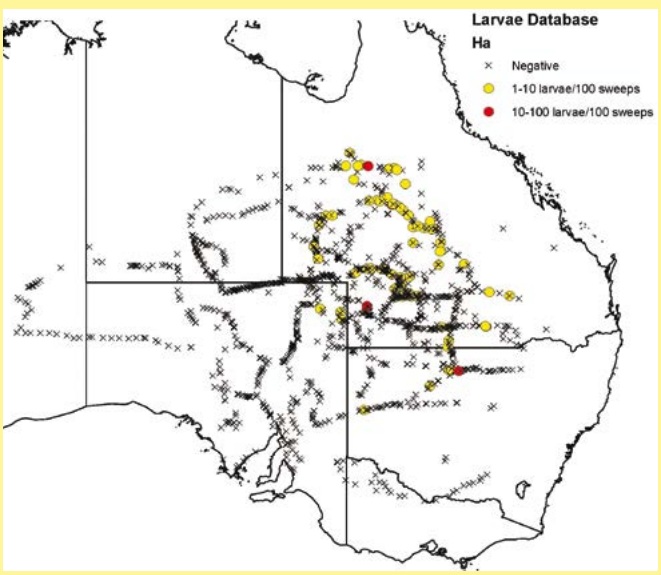


FIGURE 2: Densities of *H. armigera* larvae on inland hosts, 1987–2017



recorded larvae on 120 host plants, of which 107 were new host records. When added to the list of previously known species, the host range of *H. punctigera* includes 232 species, from 40 families.

This makes it a good candidate for the most polyphagous insect in the world.

Larvae of *H. punctigera* were present on about 50 per cent of the samples, throughout the inland (Figure 1). By contrast, *H. armigera* larvae were found on only about 4 per cent of sample sites, from 38 plant species, mostly in the northeast inland (Figure 2), and in generally lower numbers.

We assessed the suitability of host plants based on the relative incidence of larvae (percentage of sites infested) and the relative abundance (average numbers of larvae per 100 sweeps). The best hosts were annual daisies such as *Rhodanthe floribunda* (Photo 1) and *Polycalymma stuartii* (Photo 2), and annual legumes such as *Cullen cinereum* (Photo 3) and *Cullen pallidum*.

On these hosts we sometimes found more than 100 larvae per 100 sweeps, which is many more than we saw on crops such as chickpeas, faba beans, canola and lucerne around the margins of our inland study area. Given that there are millions of hectares of these native hosts in a good season, it is likely that in many years there are far more *H. punctigera* in the inland than in the cropping areas.

Rainfall is the key to the abundance of all these hosts. The most important daisy hosts have seed dormancy mechanisms which prevent them from germinating in spring or summer. Rain at these times mostly produces grasses and perennial shrubs, which are not hosts for *H. punctigera*. It is rain from April through to August which germinates the daisy hosts.

But in inland areas south of about the Queensland border, frosts usually curtail the development of larvae in mid-winter. The areas that produce the most larvae in mid-winter are therefore daisy habitats in the Channel Country of western Queensland and the Simpson Desert.

In contrast, the legume hosts can germinate in response to rain at any time. One species, annual verbine (*Cullen cinereum*) can dominate the floodplains of western Queensland – the Cooper, Diamantina and Eyre Creek/Georgina systems. These systems have been described as the world's largest natural irrigation area, and examination of Photo 3 will show you why.

The rain that feeds these systems falls far to the north and east, usually in summer. The land is flat, so water takes months to move down the floodplains, which are dissected by thousands of channels that spread the water. It is often late autumn or winter before the water is off the floodplains, and the host plants can grow.

Photo 1: An expanse of the large white sunray, *Rhodanthe floribunda* (inset), on the Darling floodplain near Wilcannia, August 2016. *R. floribunda* is a good host for *H. punctigera*.

Migration to the cropping areas

The daisy hosts senesce rapidly in early spring, leaving an environment which is unfavourable for further breeding. Moths emerging at this time migrate to the south and east, flying at night, at altitudes of up to 1000 metres where wind speeds can easily reach 60–100 km per hour. We believe the moths do not control their direction of flight but on nights when the temperature is high enough for nocturnal flight, the winds will generally be from the north or north-west, and they carry the moths towards the cropping regions in the east.

Floodplain hosts also usually senesce in spring, and are another source of emigrating moths. We believe though that a few moths remain behind, where they may survive the summer on patches of legumes which are germinated by local rain.

Cullen pallidum (Bullamon lucerne) may be a key host in this respect, because unlike most native legumes it grows in sandy country where moisture from small falls of rain is readily available to plants.

The fate of emigrating moths depends entirely on the direction and strength of the wind. Their flight speed is usually much less than the wind speed, so they have very limited control over where they end up. Wayne Rochester from the University of Queensland modelled migration in relation to the wind, and Alistair Drake and colleagues from the Australian Defence Force Academy have used radar to track their movement.

Photo 2: *H. punctigera* larvae on the daisies *Polycalymma stuartii* (poached egg daisy) and *Senecio gregorii* (fleshy groundsel) in the Simpson Desert, August 2016.

These studies suggest that while it is occasionally possible for moths to move from inland breeding areas to cropping regions in one flight, it is more likely that they will reach areas such as the mulga lands of western Queensland, or the Darling floodplain, or western Riverina. If there has been good winter and spring rain in these areas, native hosts will be abundant and larvae can survive when the weather has warmed.

Such 'bridging' areas may be the source of moths which infest cropping areas in mid to late spring.

Return migration and the Pied Piper?

One of the unsolved mysteries of the *H. punctigera* story is whether the descendants of immigrant moths ever return to the inland. While there are winds that blow from the southeast towards the inland in summer and autumn, they are generally much weaker than those which bring moths. Perhaps the discovery by Sharon Downes of CSIRO that resistant alleles for Bt toxins exist in inland populations (albeit at lower frequencies than in summer crop areas) is evidence of return migration, but there are other explanations.

Geneticists pose an interesting conundrum about return migration, known as the "Pied Piper hypothesis", after the legend from Hamelin.

The argument goes like this – Migration, like most characteristics, is strongly influenced by genes. If individuals that have genes that favour migration leave, and they or their descendants do not return, the genes for migration will eventually die out in the source population and it will become sedentary. In an environment as uncertain as inland Australia, that would be fatal. So the continued existence of *H. punctigera* suggests that return migration must occur.

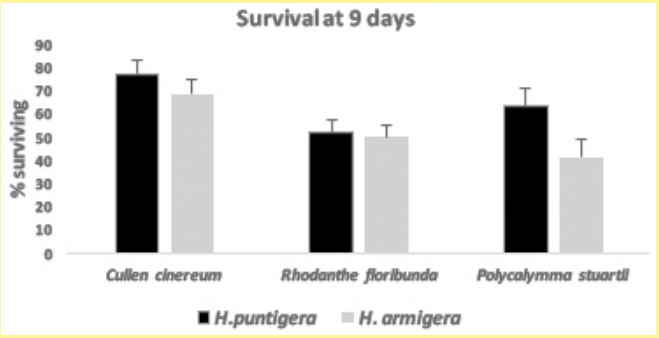
Some ecologists question the Pied Piper hypothesis though. In any case, the existence or not of return migration is perhaps the biggest question we cannot yet answer.

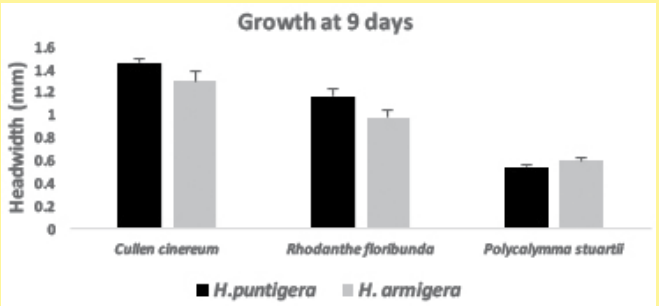
Why so few *H. armigera*?

Comparison of Figures 1 and 2 suggests that the outback is a fairly hostile environment for *H. armigera*. It becomes markedly less common going southwest from Queensland, and in central Australia it is almost non-existent. To determine whether this is because it does not handle the native hosts, we grew three plants, *Cullen cinereum*, *Rhodanthe floribunda* and *Polycalymma stuartii* in the lab and compared the growth and survival of the two Helicoverpa species (Figure 3).

Photo 3: The floodplain of Eyre Creek, near Bedourie, Queensland in May 2009. The many channels serve as a natural irrigation system, growing extensive areas of annual verbine (*Cullen cinereum*, inset), a good host for *H. punctigera*.

FIGURE 3: Comparisons of survival and growth rate of *H. punctigera* and *H. armigera* larvae on three key inland hosts





There were clear differences between the host plants, but only minor differences between the two Helicoverpa species (with the exception of survival on *P. stuartii*). While these are only three of up to 120 possible hosts in the inland, they are three of the most widespread and abundant and it is likely that any insect that could handle them as well as *H. armigera* can, should do well in the inland. We need to look elsewhere for a full explanation of the rarity of *H. armigera* there.

Perhaps the migratory strategies of the two species are different. We used to consider that *H. punctigera* was an obligatory migrant that moved every generation, while *H. armigera* was a facultative migrant that moved only when the environment deteriorated. Observations following the wet springs of 2010 and 2011 suggest it is not quite that clear-cut.

At least some *H. punctigera* remain behind if the host plants are still there. But there may still be a difference – while both species are capable of long distance migration, perhaps *H. punctigera* does it more often and that may make the difference in adaptation to such a patchy and unpredictable environment.

Implications for management

A clear implication of the capacity for polyphagy and migration that Helicoverpa spp. exhibit is that, very often, farmers are not responsible for their own pest problems. Moths can arrive, with little warning, from outside their farms or even outside their districts, and past pesticide use is largely irrelevant.

This is in contrast to less mobile pests like aphids, mites and whiteflies. Poorly chosen pesticide application can flare these pests, so ecologists call them secondary pests – meaning secondary in origin, not necessarily in importance!

So what can we do with migratory, *r*-selected, primary pests such as Helicoverpa spp.?

One option is to be ready with selective pesticides, which can be applied quickly when immigration occurs. This requires good forecasting and monitoring techniques. While these may have become less important in the transgenic era for cotton, in other crops such as grain legumes and canola, they remain crucial.

An alternative is to have built-in protection in the crop, ready for any immigration. This of course is what Bollgard II and III varieties have provided for cotton. It opens the way to fewer and more selective pesticide applications for other pests, too.

This is why entomologists see Bt cotton as a platform for IPM, not a magic bullet. But this strategy only works as long as Helicoverpa spp. remain susceptible to Bt toxins.

Resistance management strategies are critical, and in this respect our research suggests that they are particularly critical for *H. armigera* because it does not have the large natural refuges in inland Australia that *H. punctigera* does.

Unlike *H. armigera*, *H. punctigera* did not develop sustained resistance to insecticides during the era of conventional cotton, and we believe this was largely due to regular immigration of unselected insects from the inland.

It was therefore a shock to find that, during and after the Millenium Drought, the frequency of resistance alleles for Cry2Ab seemed to be increasing in *H. punctigera*. At the same time, research by Geoff Baker and Colin Tann of CSIRO suggested that we were seeing less spring immigration to cotton areas than before the drought.

In the next article we will discuss the impacts of the Millenium Drought on Helicoverpa ecology in the inland, and their implications for pest management.

Acknowledgments: I have written this article as a sole author because there are simply too many people to include them all as authors. Among the many who have contributed to this work are Alice Del Socorro, Kris Le Mottee, Holly Ainslie, Chris Jones and Rob Duthie (UNE), Gary Fitt, Colin Tann, Cheryl Mares and Tracey Parker (CSIRO), Meron Zalucki and Wayne Rochester (UQ), Peter Twine and Dave Murray (QDPI), Alistair Drake (ADFA) and Haikou Wang and David Hunter (APLC). We have also had invaluable help from many residents of the outback, who ran pheromone and light traps and assisted in many other ways. Funding has come, at various times, from CRDC and the Cotton CRC, GRDC, RIRDC and ARC. ■

Tracey Parker and Sharon Thomas (CSIRO) sorting sweep net catches from *Cullen cinereum* on the Eyre Creek floodplain near Birdsville, Queensland, May 2009. Note the area of host plants in the left middle distance, which has been extensively eaten out by *H. punctigera* larvae.

Gary Fitt and Matt Cahill (CSIRO) installing a pheromone trap and data logger on the edge of the Cooper floodplain during a dry winter (July 1987).

Peter Gregg with students and teachers from Birdsville State School. Several outback schools operated pheromone traps for the project, and in return we conducted insect collecting sessions with the children.

Rob Duthie (UNE) sampling sweep netting for Helicoverpa larvae on daisies (*Lawrencella davenportii*) in the Great Victoria Desert, South Australia, September 1991.

Genetics helps wheat fight hessian fly

By Sharon Durham, Agricultural Research Service – USDA

AT A GLANCE…

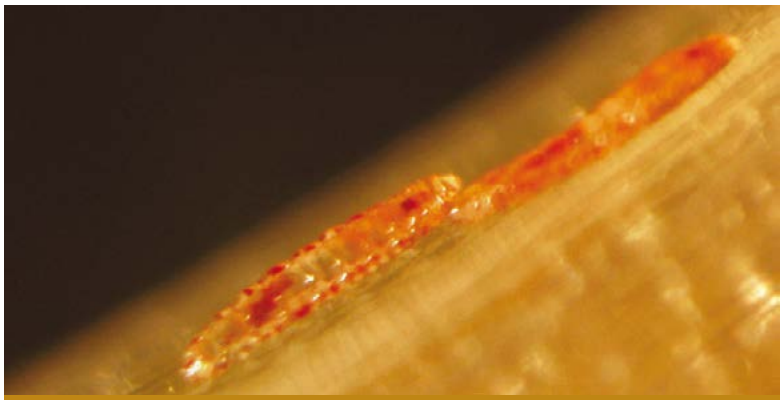
- The hessian fly damages wheat and other cereal crops.
- ARS found a gene, H33, that makes wheat resistant to hessian fly.
- Genetic markers help breeders move the gene into new wheats.
- ARS scientists devised a strategy to find markers for the H33 gene.

SCIENTISTS around the world are searching for ways to combat the hessian fly (*Mayetiola destructor*), a significant insect pest in cereal crops like wheat, barley, and rye. These insects lay eggs on the plant's leaves, and the growing larvae use chemical warfare to hijack the plant's genes to benefit themselves, causing severe plant stunting and inability to produce seeds.

Agricultural Research Service (ARS) molecular biologist Christie Williams and her colleagues in West Lafayette, Indiana, discovered a new wheat gene – called H33 – that protects the crop against hessian fly attack. This gene is effective throughout the US, but it is desperately needed in the southeast states, where hessian fly resistance in older wheat varieties is failing.

Initially, the research that identified H33 did not detect molecular markers that were close enough to the gene to be useful for marker-assisted selection – a streamlined plant-breeding method. Consequently, this much-needed gene could not be used efficiently by breeders.

"Without close markers, the resistance gene could be lost during the breeding process, leaving the new cultivar still susceptible to the insect," says Christie. "In addition, if the markers aren't close enough to the gene, undesirable genes that are near H33 could be dragged along with the markers into the receiving wheat genome. Those tag-along genes can decrease seed quality or cause the crop to become susceptible to other diseases."



Hessian fly larvae (0.1 millimetre). (PHOTO: Subhashree Subramanyam)

In order to locate markers that were close enough to H33, Christie and her colleagues devised an unusual strategy aided by high-throughput DNA sequencing to target their search to a small region of the chromosome that contained the resistance gene. "The strategy let us find that needle in the haystack," Christie says.

The targeting strategy led Christie to discover five new markers that are very close to H33. "These markers were converted into a convenient and inexpensive format for breeders to use while moving the H33 gene into new cultivars." ■

An adult hessian fly on a leaf. (PHOTO: Scott Bauer)

The good oil on leaves and stems of plants

RESEARCH by CSIRO now makes it possible to produce oil in the leaves and stems of plants as well as the seeds which promises to be a game changer in the global production of renewable oils. US-based company Amfora and CSIRO have signed an agreement that will advance development and commercialisation of the technology to produce energy-rich feed for livestock.

Innovation Leader with CSIRO Agriculture and Food, Allan Green, said that this was the first of many applications of the technology, which could also be used for human food, biofuels and industrial uses.

"Previously it has only been possible to extract oil from the oil-rich seeds and fruits of some specialised plants, such as canola, soybean, sunflower, coconut and oil palm," Allan said.

High oil content in vegetative tissue

"What we have been able to do is switch on this high-level oil production in vegetative tissue, such as in stems and leaves, as well."

In some plants, the research team has been able to get around 35 per cent oil content into vegetative tissue – the same amount as in many oilseed crops.

"If the technology were applied to existing oil crops it could potentially treble oil productivity and greatly expand renewable oil production worldwide," Allan said.

"We are using solar energy captured by the plant to convert the leaf's starch reserves into more energy-dense oil molecules, which significantly increases the energy value of the vegetative tissue where the oil accumulates."

CSIRO Chief Executive Larry Marshall said the work demonstrates the capacity of Australian researchers to develop innovative solutions for global industries.

"It is estimated that in 20 years' time we will need 50 per cent more plant-based oils just to meet the nutritional needs of a global population, and there is also a growing demand for renewable biofuels," Larry said.

"A transformational approach was needed to solve the increasing demand for plant oils within the limitations of our current agricultural footprint.

"CSIRO's relationship with Amfora – under which CSIRO will become a significant shareholder – is an excellent demonstration of our *Strategy 2020* in action.

"We are driving profound global impact from this breakthrough innovation, benefiting Australian farmers and securing a revenue stream back to Australia to support further research that will keep Australia at the leading edge of competition."

Amfora will use the technology to develop oil content in the vegetative tissue of corn and sorghum, meaning they can market a feed for dairy farmers that does not require them to purchase additional oils, such as tallow or cottonseed, to supplement feeds.

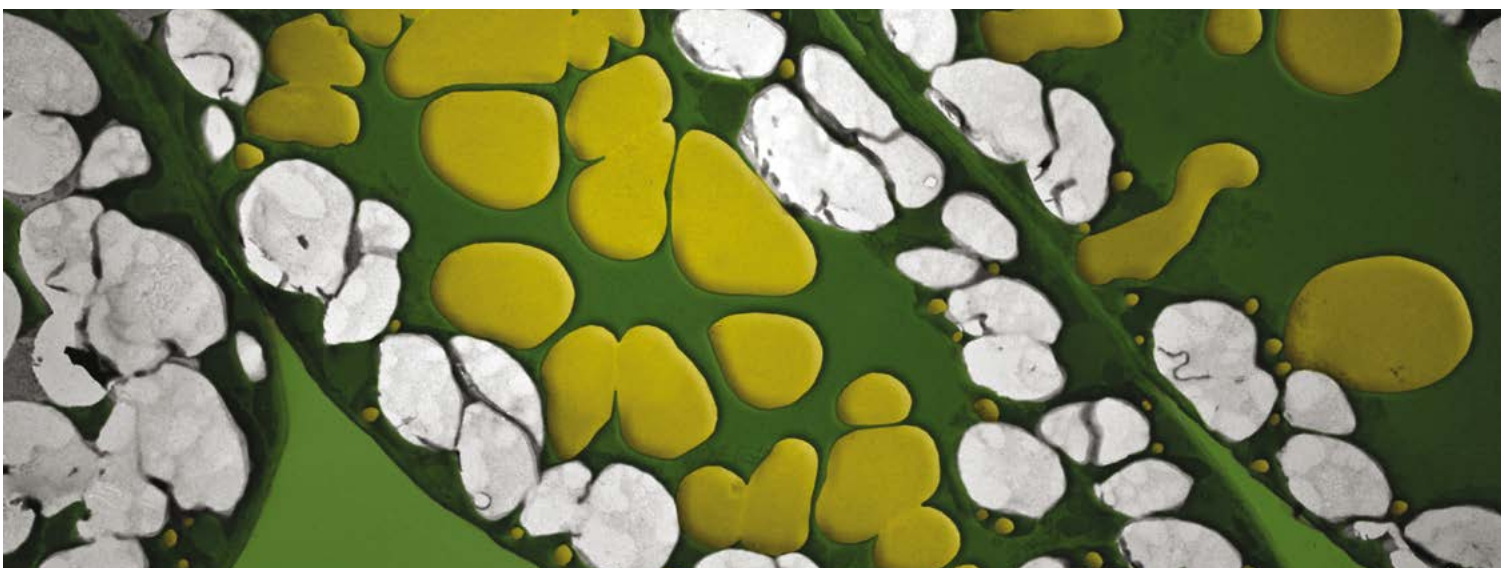
Dairy cattle require around seven per cent fat in their diet to produce milk. If their feed already contains this fat in the form of oil then this means less agricultural land is needed to produce feed and fewer greenhouse gas emissions are produced from feed production.

The agreement with Amfora is the first major application for the high oil technology. It provides a direct path to market as the oil does not need to be extracted from the leaves before it is fed to cattle.

Future applications, such as the production of industrial oils and bio-based diesel, will require further industrial supply chain development to customise techniques for extracting the oil and converting it to suitable products.

More about the agreement

CSIRO granted Amfora a worldwide, exclusive license to its technology for use in the development of specified forage crops. CSIRO also participated in Amfora's Series A financing along with Spruce Capital Partners, a venture capital firm based in San Francisco, California and co-manager of the MLS Fund II. ■



Research by CSIRO now makes it possible to produce oil in the leaves and stems of plants as well as the seeds which promises to be a game changer in the global production of renewable oils. Amfora will use the technology to develop oil content in the vegetative tissue of corn and sorghum.

Peptides could revolutionise how food is grown

A NEW Australian study of peptide hormones critical for plant development could result in wide-ranging benefits for agriculture, tissue culture, and related industries – and even improve knowledge of peptides in humans.

The study, involving University of Queensland and University of Sydney researchers, synthesised and examined the function of CLE peptides, a relatively new class of the peptide hormone family in plants.

Dr Brett Ferguson of the Centre for Integrative Legume Research, in the School of Agriculture and Food Sciences at UQ, said the research was exciting because CLE peptides had essential roles in regulating plant growth and development, increasing productivity as well as adaptation to environmental factors.

Dr Brett Ferguson says plant peptides could help feed more people for less. (ABC News)

"The CLE peptides can potentially be used to manipulate plant growth," he said.

"Even a small increase in yield can be massively important to agriculture – increasing food production and food security, whilst enhancing agricultural sustainability.

"Other studies have demonstrated that a variant of one CLE peptide can result in bigger tomato fruit."

New research into the plant signalling system

"The findings open up new areas of research to study the specificity of function/structure in the CLE peptide signalling system in plants.

"This is a fast-growing research area due to its importance to agriculture, food, and other industries that involve plant growth and development."

WHAT IS A CLE PEPTIDE?

- CLE peptides (CLavata3/Embryo Surrounding Region Related) are a group of peptides found in plants that are involved with cell signaling. Production is controlled by the CLE genes.
- Upon binding to a CLE peptide receptor in another cell, a chain reaction of events occurs, which can lead to various physiological and developmental processes.
- This signaling pathway is conserved in diverse land plants.

Brett said as well as relevance to plant development, the findings were relevant to animal peptide signalling.

"CLE peptides are specific to plants, but peptides and associated receptors are also found in animals/humans. Understanding mechanisms in plants can benefit our understanding of similar mechanisms in humans," he said.

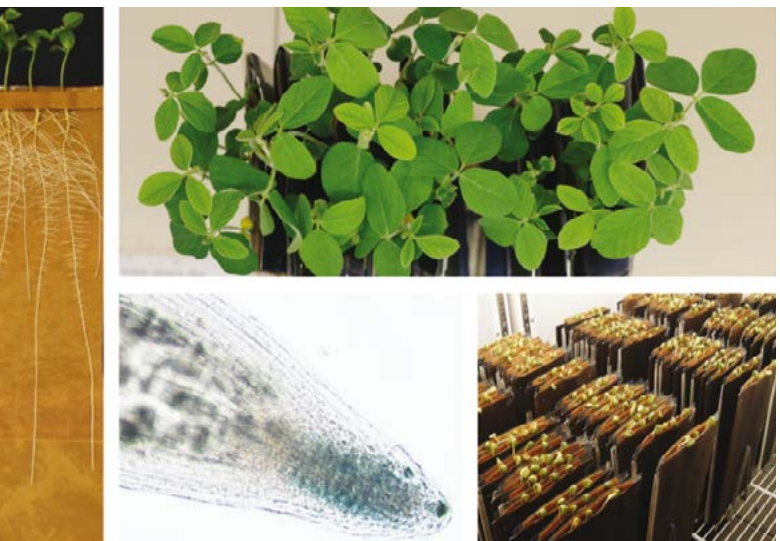
CLE peptides are very difficult to detect and extract from plants due to their small size and extremely low concentration. As a result, the peptides need to be chemically synthesised to test their function in biological assays.

Complex chemistry

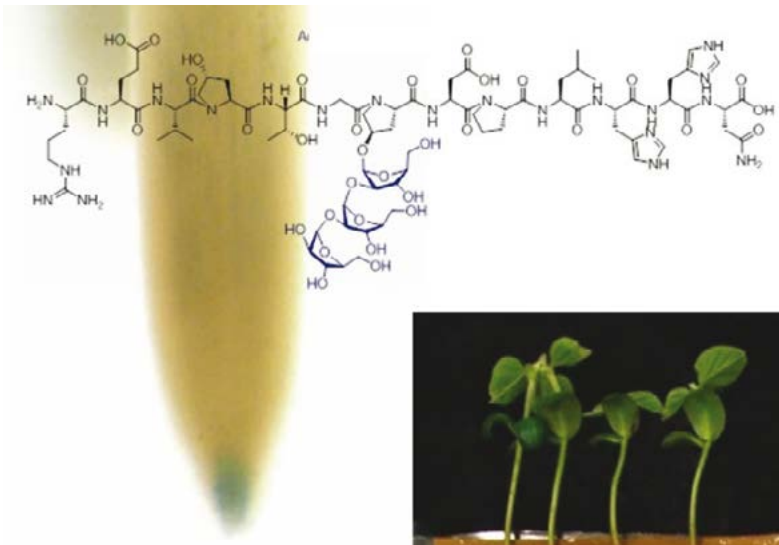
"This is sophisticated chemistry with biological relevance," Brett says. "Creating the target molecule then testing its biological function is not always done, especially when the molecule, such as the CLE peptide, is complex.

"The few CLE peptides that have been detected have all been modified with three arabinose sugar molecules linked together. But this 'triarabinose building block' is extremely difficult to synthesise. In our study, this important building block was synthesised using cutting-edge chemical synthesis methods.

"The building block that has been produced by the Payne Laboratory (School of Chemistry, the University of Sydney) is now



The discovery of a class of hormones regulating growth in plants could lead to better yielding varieties that provide more food. (Supplied: University of Queensland)



The CLE peptides are difficult to detect in plants, but the researchers have been able to synthesize one that monitors root growth. (Supplied: University of Queensland)

readily available to access synthetic CLE peptide hormones to test their activity in plants using feeding studies."

The study used the building block to chemically synthesise CLE40, which is a CLE peptide that modulates root development (by controlling the stem cell population of the root).

"This is obviously a very important peptide hormone to plant growth," he said. "We also developed a new assay to feed the CLE40 peptide and monitor root growth.

"Using this assay, we showed that the building block is important to CLE40 activity. Modifying root architecture via key developmental factors is viewed as a pivotal step in enhancing agricultural sustainability and food security.

"The building block can now be used to synthesise other CLE peptides, which can subsequently be used in feeding studies to establish their activity."

Tremendous potential for agriculture

Brett said CLE peptides found to modify aspects of growth or yield had tremendous potential in agriculture (increased food production), tissue culture (potential to stimulate shoot or root development), floriculture (potential to enhance flowering), and other industries that relied on plant growth.

This might be achieved by feeding, or through targeted breeding or genome editing techniques.

The study, "Arabinosylation Modulates the Growth-Regulating Activity of the Peptide Hormone CLE40a from Soybean", is published in *Cell Chemical Biology*.

Brett's group also recently published the complete CLE peptide family of two legume species in Scientific Reports, in addition to publishing another article in Scientific Reports on a CLE peptide receptor having a role in regulating shoot architecture.

For more information:
Dr Brett Ferguson, b.ferguson1@uq.edu.au, +61 7 3346 9951. ■

The study has identified a class of hormones in legumes that are responsible for plant growth and development.
(Supplied: University of Queensland)

Researchers identify gene to help hybrid wheat breeding

AUSTRALIAN researchers at the University of Adelaide have identified a naturally occurring wheat gene that, when turned off, eliminates self-pollination but still allows cross-pollination – opening the way for breeding high-yielding hybrid wheats.

Published in the journal *Nature Communications*, and in collaboration with US-based plant genetics company DuPont Pioneer, the researchers say this discovery and the associated breeding technology have the potential to radically change the way wheat is bred in Australia and internationally.

"Wheat is the world's most widely grown crop, delivering around 20 per cent of total food calories and protein to the world's population," says Dr Ryan Whitford, Hybrid Wheat Program Leader at the University of Adelaide's School of Agriculture, Food and Wine.

"But to meet increased food demand from predicted global population growth, its production needs to increase by 60 per cent by 2050. One of the most promising options to meet this demand is for farmers to grow hybrid wheat varieties, which can offer a 10 to 15 per cent yield boost relative to conventionally bred varieties that are currently on the market."

Hybrids could benefit a wide cropping area

In Australia, hybrid wheat would probably best serve those wheat growers in the higher yielding, high rainfall zones along the eastern seaboard, but hybrids also could provide improved yield stability in the more challenging growing regions of Australia.

Hybrid wheats result from crosses between two carefully selected pure wheat lines. But the challenge to produce hybrid wheat is in the breeding and commercial multiplication of the hybrid parent seed. Wheat is a self-pollinator while the production of hybrid seed requires large-scale cross-pollination.

"Hybrids are widely used for the cereals corn and rice but developing a viable hybrid system for bread wheat has been a challenge because of the complexity of the wheat genome," says Ryan. "We have now identified a gene necessary for cross-pollination in wheat which can be used in large-scale, low-cost production of parent breeding lines necessary for hybrid wheat seed production."

In the US, DuPont Pioneer has developed an innovative breeding technology for corn called Seed Production Technology (SPT) used to bulk-up parent breeding lines for hybrid production.

"The pollination gene is 'biologically contained' to the breeding process and does not make its way past the grandparent stage in producing the end-user hybrid seed," says Dr Marc Albertsen, Research Director, DuPont Pioneer.

"This identified pollination gene is the key step for a similar technology for wheat and could dramatically increase the efficiency of hybrid wheat seed production." ■

Cutting edge research brings lentils in from the wild

IN cutting-edge research aimed at breeding better lentils, a partnership between the University of Saskatchewan (Canada) crop scientists and genomic big data company, NRGene (Israel) has successfully sequenced two wild lentil genomes – the largest legume genomes ever assembled.

Thanks largely to advances in plant breeding at the University of Saskatchewan, Canada is the world's leading exporter of lentils. Millions of tonnes of Canadian lentils are shipped to India, Pakistan and Bangladesh every year where this vegetable-based protein serves as a critical food source.

The research comes under the umbrella of the Genome Canada funded ($7.9 million) project – *Application of Genomics to Innovation in the Lentil Economy (AGILE)*. It is led by University of Saskatchewan scientists Kirstin Bett and Bert Vandenberg.

With the help of NRGene's genomic assembly and analysis technology, the research is expected to empower future breeding efforts aimed at enhancing lentil yield and quality.

"NRGene's technology has dramatically accelerated our research, which aims to shed light on lentil domestication and adaptation," said Kirstin. "Through identifying beneficial traits from wild relatives and integrating them into the genome of the domesticated lentil, we can now develop lentil varieties with much improved vigour, resilience, and productivity.

Maintaining sustainable lentil production will play an important role in addressing the world's need for an ecologically sound protein source that is also highly nutritious."

Kirstin's group leads the international lentil genome sequencing initiative, which has resulted in the release of a 'reference genome' – a complete genome sequence – for a Canadian-cultivated lentil variety. Now with additional genomic information from the wild species, the researchers have a much broader view of genes and pathways that enable lentils to thrive in volatile climatic conditions.

Kirstin points out that to date, breeders have only been able to access a small fraction of the total germplasm diversity in existence, which hinders producers' ability to meet growing global demand. With its focus on wild lentil genomes, the project is aimed at introducing genetic diversity with great precision and speeding up the breeding cycle to provide breeders with faster access to better lentil varieties.

Wild wheat also sequenced

The University of Saskatchewan Crop Development Centre is also working with NRGene to sequence other major crops. A huge step forward in crop genomic research was the release earlier this year of the wild Emmer wheat genome sequence.

This was generated using NRGene technology and involved University of Saskatchewan scientists. Emmer wheat is the wild form of all the domesticated wheat in the world.

The work was published in *Science* in July, 2017.

"Our partners at the University of Saskatchewan are aggressively pursuing the quest to identify essential traits that strengthen the genetics of the crops that feed the world," said NRGene CEO Gil Ronen. "We look forward to our continued partnership to disrupt the cycle of world hunger by offering hardier, more nutritious plants."

NRGene is a genomic big data company developing cutting-edge software and algorithms to reveal the complexity and diversity of humans, plants and animals for supporting the most advanced medical research and sophisticated breeding programs.

The Crop Development Centre in the University of Saskatchewan, College of Agriculture and Bioresources is a field crop research organisation that seeks to improve economic returns for farmers and the agriculture industry by improving existing crops, creating new uses for traditional crops, and developing new crops. ■

University of Saskatchewan crop scientists Kirstin Bett and Bert Vandenberg are identifying benefical traits from wild lentils. These traits can then be integrated into modern domesticated lentil varieties for greater adaptation in hostile climatic conditions.

Testing alternative lime sources and the impact of deep ripping

TRIALS established this year in Western Australia's eastern grainbelt aim to find a cost–effective way of improving and maintaining production on subsoil–constrained sandplain soils in low rainfall areas.

Researchers are investigating the effectiveness of local carbonate sources, as alternatives to traditionally-used coastal lime sand, in reducing subsoil acidity. They are also investigating the effectiveness of deep ripping and cultivation to alleviate subsoil compaction, and their effects on soil acidity.

The trials are being conducted by the Department of Primary Industries and Regional Development (DPIRD) as part of the Grains Research and Development Corporation's (GRDC) five-year investment in the Soil Constraints suite of projects in the western region.

DPIRD senior development officer Caroline Peek said crops in the trial plots which were deep ripped were significantly greener, and had better root systems, during the very dry 2017 growing season and it would be interesting to see if this translated into higher yields.

"Crop plants growing in areas where inclusion plates were used (which help incorporate surface material into the subsoil) also looked better and had significantly stronger roots than plants growing between the areas where plates were used," she said.

Caroline said it was important to address constraints in sandplain soils common in the eastern grainbelt given increasingly variable growing season rainfall and the need to get the crop out of the ground from often limited rainfall.

"Most of these soils are naturally low in pH and high in aluminium, and cropping continues to acidify these soils," she said.

"With the use of heavy agricultural machinery, some of these soils are also prone to subsoil compaction."

Caroline said the continued application over time of a neutralising source such as lime sand had been shown to improve and maintain the productivity of these soils.

Root profiles at the Kalannie trial site from the 'nil treatment' plot that was not deep ripped or cultivated, compared with significantly stronger roots where inclusion plates were added to a deep ripper, helping to incorporate topsoil down the soil profile. (PHOTO: DPIRD)

"But many growers in the eastern grainbelt find the transport cost of coastal lime sand to be prohibitive at the rates required," she said.

"It is also thought that low rainfall in the area may limit the movement of lime sand down the profile into the subsoil – which adds to grower concerns about the time it will take to achieve a return on their lime investment."

Caroline said some growers were interested in mining and applying local neutralising sources which were often associated with subsoils of lower value red calcareous clays.

"Previous research has shown that very fine material reacts more quickly with the soil and that adding inclusion plates to a deep ripper can achieve good results as it helps to ameliorate subsoil compaction and allows some surface material to become incorporated in the subsoil," she said.

Caroline said the trial, which will continue in coming seasons, was being conducted at Kalannie.

The pH levels at the trial site were 4.5–4.8 at 0–10 cm from the soil surface, and 4–4.2 at 40–60 cm from the surface, with high levels of aluminium.

Treatments included crushed carbonate rock applied at 4.5 and 9 tonnes per hectare; 'screened' carbonate soil applied at 5.5 and 11 tonnes per hectare; 'bulk' carbonate soil applied at 30 tonnes per hectare; and, lime sand applied at 4 tonnes per hectare.

Deep ripping treatments – tested in combination with the carbonate treatments included deep ripping to a depth of 50 cm, deep ripping with inclusion plates to a depth of 45 cm; and offset discs (cultivation).

The wheat variety sown in the 2017 trial was Scepter sown dry on May 21, followed two days later by rain which triggered germination of the crop.

Caroline said the season had been very dry but about 90 mm of rainfall was received in August and September, which would influence the final 2017 trial results.

The Kalannie trial site in mid-August showing Scepter wheat on a plot not ripped, left, compared with wheat on a plot deep–ripped with inclusion plates. (PHOTO: DPIRD)

More information about ameliorating subsoil acidity and compaction is available at https://www.agric.wa.gov.au and https://grdc.com.au ■

Australia's southern winters are drying out – here's why

By Ben Deacon and Kate Doyle – ABC Weather

AT A GLANCE…

- This winter was particularly dry given there was no El Niño event;
- Winters in Australia's south are drying out, affecting farmers; and,
- Scientists say it is not just due to climate variability.

WINTER rains are in decline across southern Australia, and while it is too early to say beyond doubt it is due to climate change, scientists say it is not just about climate variability.

According to the Bureau of Meteorology, June was the driest on record for large parts of southern Australia, and the winter as a whole across Australia was the ninth driest on record.

"It's actually quite unusual for us to get such a widespread dry through the winter without having an El Niño," Bureau of Meteorology senior climatologist Blair Trewin said.

El Niño often brings dry conditions to Australia, but this year it is in neutral.

"It's almost more about what hasn't been happening," Blair said.

Normally in winter, storms come up from the southern Indian Ocean and clip the bottom of Western Australia, delivering rain to the south of the country.

But until mid-July, the storms largely missed the continent.

What kept the storms south is a little-known climate driver called SAM, or Southern Annular Mode.

When SAM is positive, as it was in early winter, storms stay south and southern Australia experiences clear, calm days and cold, frosty nights.

SAM went negative in late July and the southern fringe of Australia was hit by a series of rain-bearing fronts.

Climate driver getting stronger in winter

The August rains saved crops in far southern areas, but did not reach up far enough to help farmers in central New South Wales or WA's northern wheatbelt.

Instead, an area of high pressure called the Sub Tropical Ridge dominated the continent, confining rain to the south.

The Sub Tropical Ridge is a climate driver worth paying attention to because over the past few decades, it has been getting stronger in winter.

As a result, winters in the south of the country are drying out.

Agronomist Ben Hawken said he had never seen crops in the Central-West of New South Wales damaged by frosts like he had this winter.

"We had 50 to 55 below-zero days this season. Normally we'd have half a dozen," he said.

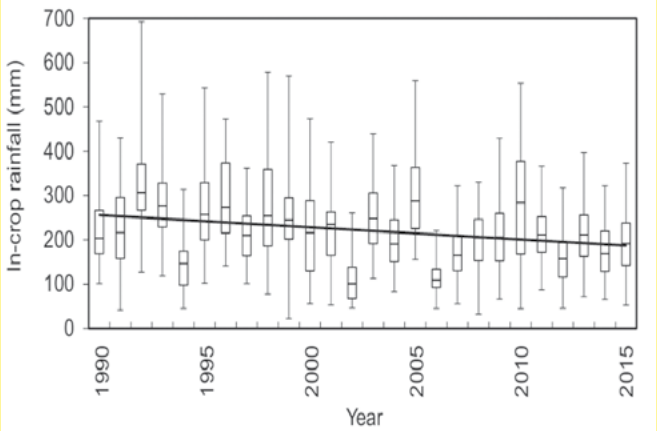
Winter rain in Australia's southern wheatbelt has declined by 28 per cent since 1990. (ABC News: Greg Nelson)

Ben Hawken says the NSW Central West had 50 to 55 days of below-zero days this winter. (ABC News: Robert Virtue)

Frosts combined with low rainfall across all the southern states have jeopardised many farmers' entire winter crops.

"Yesterday I looked at one farmer's five paddocks. We wrote off three of them," Ben said.

FIGURE 1: Rainfall data from 50 weather stations in Australian wheat-growing areas from 1990 to 2015 shows large variability within and between years, but also an overall downward trend



(Supplied: Zvi Hochman)

Rainfall continues to decline in the south

According to the Bureau of Meteorology, May to July rainfall has reduced by about 19 per cent since 1970 in the south-west of Australia.

There has been a decline of about 11 per cent since the mid-1990s, in the April–October growing season rainfall in the continental south-east.

CSIRO Agriculture and Food senior principal research scientist Zvi Hochman said winter rain in Australia's southern wheatbelt had declined by a whopping 28 per cent since 1990 (Figure 1).

"I was surprised as anyone to find the extent to which that trend, across the 50 weather stations, is there," Zvi said.

"Yes, it varies geographically, but it is still a very strong trend.

"A period of 26 years is not sufficient to say without any doubt that it is climate change. But it is long enough to say without any doubt that it's not just climate variability.

"There is a one in a hundred billion chance that this trend is by chance alone."

Farmers well versed in adapting to changing climate

Zvi said Australian grain growers had been very good at adapting to the reduced rainfall.

"The farmers have been able to actually cope with that by adopting new techniques or just tightening their management around their farming practices, and there is still room to go in that regard," he said. ■

Sorghum variety beats heat where others failed

RUNNING three cattle breeding and fattening properties near Springsure in central Queensland, freight costs can be significant for Sid Godwin.

The location of the enterprise, headlined by the main 'Tanderra' property means it is most economical for Sid to grow his own grain for cattle fodder.

"Basically for me to cart grain in costs a fair bit of money – there's not a lot of close sorghum growers and so it's close to $50 a tonne freight cost every time I want to purchase sorghum," he explains.

"It means we try and grow as much of our own grain as we can, because we do use a significant amount of it every year."

Heading in to the 2016–17 summer Sid was looking for a new sorghum variety to try and his agronomist recommended Pioneer brand G44 hybrid sorghum.

Resistance to long, hot and dry spells needed

It has one of the most important characteristics Sid wants in any sorghum – resistance to long hot spells with very little rain. While the sorghum was planted on a full profile of moisture, the 2016–17 season deteriorated quickly.

"Conditions were pretty ordinary when we planted on September 27, 2016 – we had 6.5 mm on September 29, 10 mm on October 22, nothing at all in November, and then four small falls in December that added up to 50 mm," he says.

"By that stage it was 60 to 70 days in and the sorghum had flowered and was filling heads, so even that December rain was too little too late.

"It wasn't enough to affect the yield of any substance – the G44 went a very long time on next to no rain to produce what it produced," he says.

The dry conditions were accompanied by extreme heat during flowering, meaning the sorghum crop had everything against it.

"G44 handled the heat incredibly well, you just can't fault it – at no stage did it look like it was going to curl up and die," he says.

"It was quite impressive to see how it grew, and because of the G44 staygreen characteristics, it just blew us away how it just seemed to stand up."

Sid says the yield performance of 1.88 tonnes per hectare was an excellent result given the tough season.

"There's no way in the world you can ask for any more, I was over the moon with that, and even more so with the quality of the feed – the majority was SOR1, so I can't fault it considering what it went through.

"I think it goes without saying there wasn't a single spring crop of dry mungbeans in the Central Highlands that survived the dry, hot conditions, let alone sorghum – nothing else made it through.

The only thing that got us over the line, I believe, was that we used G44 – I really don't think there was any other sorghum around that made it," Sid says. ■

Sid Godwin says the yield performance of 1.88 tonnes per hectare was an excellent result given the tough season.

Plant scientist first Australian to win top American award

THE University of Western Australia's internationally recognised authority on herbicide resistance in plants, Professor Stephen Powles, has won the American Chemical Society International Award for Research in agrochemicals.

Steve is the first Australian to win the award, which is given to a scientist who has made outstanding contributions to the field of agrochemicals at the international level, with their vision and sustained contribution having opened new horizons for investigators in their field and beyond.

Director of Australian Herbicide Resistance Initiative at UWA's School of Agriculture and Environment, Steve was recognised for his long-standing research contribution to identifying the role of cytochrome P450 enzymes in endowing herbicide resistance in plants.

Steve is one of the world's most highly cited agricultural scientists and is widely regarded as a foremost expert in herbicide resistance in plants.

A Fellow of the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering, Steve and his team have more than 250 research papers published on herbicide resistance.

Steve was nominated for the award by Dr Todd Gaines of Colorado State University. Todd is a former postdoctoral student of Steve's who spent three years as a researcher at UWA before returning to the US.

Steve will receive the award at a special symposium organised in his honour at the meeting of the American Chemical Society in Boston in August 2018.

'Highly Cited Researcher' Professor Stephen Powles.

And the accolades keep coming...

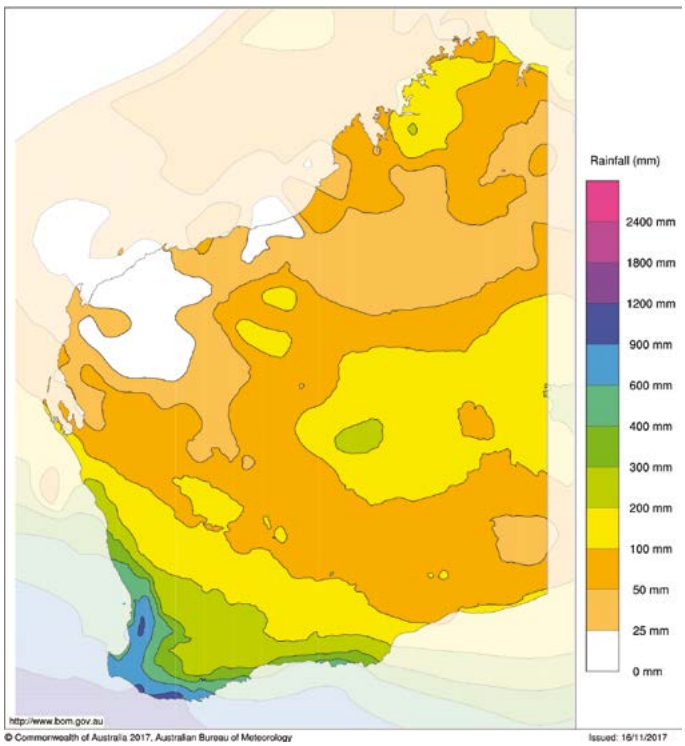
In mid November, Steve was also honoured as a Web of Science Highly Cited Researcher. This 'naming' is awarded to the top one per cent of the most cited scientists around the globe in each of 21 category disciplines.

For the category discipline of agricultural science, there are 156 global scientists who are Highly Cited Researchers. In 2017 there are only six Australians in this highly esteemed group and Steve is the only crop/weed scientist among the six. ■

District Reports...

Western region

Western Australia rainfall totals (mm) April 1 – November 16, 2017
Australian Bureau of Meteorology



After an extremely dry start, many grain producing areas of Western Australia have recorded near average growing season rainfall totals.

WESTERN AUSTRALIA SUMMARY

The resilience of Western Australia's grain production capacity is evident as late season grain fill moves the 2017 harvest from ordinary to average, with a 6.9 per cent increase in estimated total state production from October to 12.33 million tonnes. The exception to this is in the east and north east wheatbelt where some growers who were facing total crop failure in July may now achieve a 'below cost recovery' season.

Given the generally late start to harvest this year, there could be more upside to these estimates over the next six weeks. Late rains in September and mild temperatures in October enhanced favourable finishing conditions resulting in many crops harvested to date yielding "better than they look".

So far, early deliveries of barley from around the state have tested low for protein, have good grain size and some germ end stain. The indications are that this trend of low protein grain will continue as growers were generally sparing with nitrogen applications as the season improved to a far greater extent than was expected.

Early canola grain yields have been varied with some good yields and some low yields in the same region. Oil percentages have been in the high 40s in most cases.

Very little wheat has been harvested across the state so far, although judging by the deliveries of other crops it is likely grain yields will be higher than they look and grain protein low.

Lupin grain yields have been low in the north of the state with most likely to be retained on-farm for livestock feed. The lupin crops improve as you go south and lupins from these regions will make up a greater percentage of the lupin crop tonnage than normal.

Oats for grain harvested so far has been good quality though down in yield. Oats for hay are mostly baled up now in the central and north of the state, following a very drawn out process from light rainfall events.

Geraldton Zone

The zone continued to have mild conditions in October which has resulted in a slight increase in wheat tonnage estimates for this report. Wheat in the zone will yield slightly more than previous estimates with the reduction in area planted holding back expected tonnages.

Lupin and canola tonnage estimates have been reduced. The mild spring has benefited these crops but the variability across paddocks is resulting in lower grain yields.

It is clear now that more lupin and canola crops should have been sprayed out and fallowed in the eastern areas, as yields are not high enough to return a profit for some paddocks. It is expected most lupins harvested will be retained on-farm.

There is a general observation that the Roundup Ready and Triazine Tolerant hybrid canola varieties handled the difficult start and growing conditions this year better than open pollinated canola varieties.

The Midlands

There has been a slight increase in expected tonnages for wheat, barley and canola from the western regions of the zone, although there is no change in the eastern areas where most of the wheat is grown in an average year.

Harvest has been later starting than normal due to the rains in September and cool temperatures in October. Indications from grain deliveries so far are that grain protein is low, even in low yielding cereal crops, and canola yields are not as high as expected.

Noodle wheat tonnage will be down this year and will struggle to be 200,000 tonnes for the region.

Kwinana West

The western areas of the zone are just starting to harvest barley and canola with grain yields so far very good. The grain yields are as expected, or higher than expected. The barley is low in protein and most paddocks with a good yield will struggle to make malt. Canola oil percentage quality is in the high 40s and grain yields are as expected. It appears so far there has been little frost-affected area.

The wheat tonnage estimates have been increased this month based on the early deliveries of barley and canola, as in most cases the yields are better than they look. Wheat tonnage estimates have been conservative in the past two GIWA Crop Reports as it was uncertain how much yield could be made up from late tillers and grain size.

Kwinana East

The wheat tonnage estimates for the eastern regions of the zone close to and south of the Great Eastern Highway have increased in this report based on early deliveries. Grain yields are better than expected and even though below average in most cases, the large areas contribute a lot of tonnes to the region.

District Reports...

Most of the increase in wheat tonnage estimates for the state has come from the West and South East Kwinana zones.

Western Albany

Tonnage estimates for the Western Albany port zone have been left unchanged this month for all crops as there has been little or no harvest activity so far.

There is likely to be more frost affected crop than first thought based on early reports from further east and south. The impact from frost on total tonnage for the region is not expected to be high, although the range in potential yield from one paddock to another is making it difficult to predict total tonnages. The better crops look very promising, but there are a significant number of paddocks that are not going to yield near their potential due to a range of management factors during the growing season.

The general sentiment is that there is some upside to tonnage estimates for the region.

Southern Albany

There are some early barley crops being harvested in the northern parts of the zone and these have generally tested low or right on the edge for protein acceptable for malt. In the frosted areas, the combination of screenings and low protein have reduced the potential tonnage that will make malt standards. Grain yields have been very good so far. Frost looks to have been more widespread than first thought and will impact on tonnages of all grains in the region.

Very little canola has been harvested to date in the area.

Tonnage estimates have been left unchanged from October as it is too early to estimate the effect on grain yield from the frost from what has been a generally above average season for the region.

Eastern Albany (Lakes Region)

Tonnage estimates for the region have increased slightly for wheat and barley, and reduced slightly for canola.

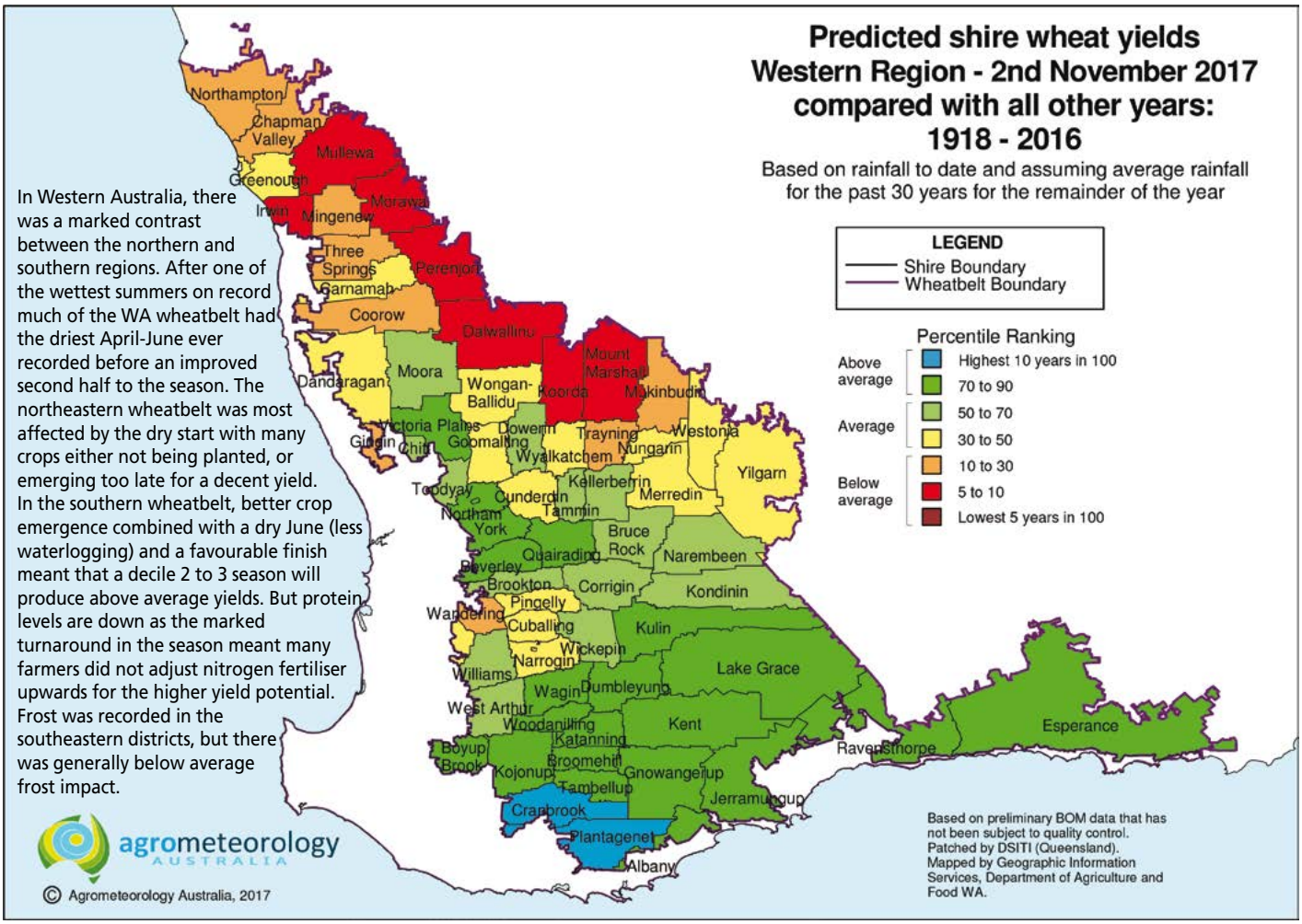
Frost affected crops for the region appear to be confined to the low areas where frost can usually be a problem. The lack of frost combined with an above average growing season has contributed to many growers looking forward to an above average harvest.

The cereals look to have come through the difficult start to the season better than canola – as is the case for most of the state.

Lupin crops have podded up well and should yield above average for the region.

Esperance Zone

Harvest of canola and barley has been underway for a couple of weeks in the regions away from the coast. Canola grain yields have been variable and generally lower than expected. Late sclerotinia and blackleg leaf infection may have contributed to this. Some of the lower yielding canola paddocks may also be



District Reports...

November–December 2017

due to frost. Oil percentages have been excellent and mostly in the high 40s.

Barley has yielded well with good grain size, although germ end stain and low protein are limiting how many tonnes are being accepted as malt. Grain yields of the newer feed varieties have been well above the malt varieties in most cases.

As little or no wheat has been harvested yet, there are questions on how the yields will go.

GIWA gratefully acknowledges the support of DPIRD and contributions from independent agricultural consultants and agronomists in the production of this report.

GIWA Crop Report – November 10, 2017

NORTH

Since my last report conditions have been favourable in the northern region for grain crops with a cool September and October. Rainfall was also above average for most of the district during these months. These conditions have also meant a late start to harvest for most inland areas. Some coastal areas have started harvest at about the normal time.

Harvest is now underway on almost all farms. But across the landscape crop yields are a real mixed bag. Soil type and luck of the rainfall draw are again the big differences. Some areas that were lucky enough to have a double digit rainfall in late May are looking at an average or better season. But most of the region has endured an almost record dry period for April, May and June.

Late rain has given some useful yields

This is reflected in crop performance but with generally good rains from mid-July on, crops are delivering useful yields in what was looking like a disaster.

Wheat is again the solid performer. Good loamy paddocks in western areas where some useful rain fell in May, are yielding in the four tonnes per hectare range – while poor low water holding capacity soils close by, will harvest less than a quarter of that. Most growers are happy with their wheat crops and quality is generally good. Nitrogen applications were left off many farms due to the very dry start to the season and hence some crops have low protein levels.

Canola is a mixed bag with some of the better grown crops not yielding as well as they appeared they would. But most canola crops are around what growers expected. Insects have taken their toll on some crops that were sprayed too late. Canola yields ranges from 0.2 tonnes per hectare in the very dry south-east up to two tonnes on coastal loams with the May rainfall. Oil contents are generally very good at 40 to 50 per cent with most at the top end of this range.

Barley has yielded well and many growers are getting malt varieties into the top grade. Again yield has followed soil type. Yields are from one tonne up to around three tonnes per hectare.

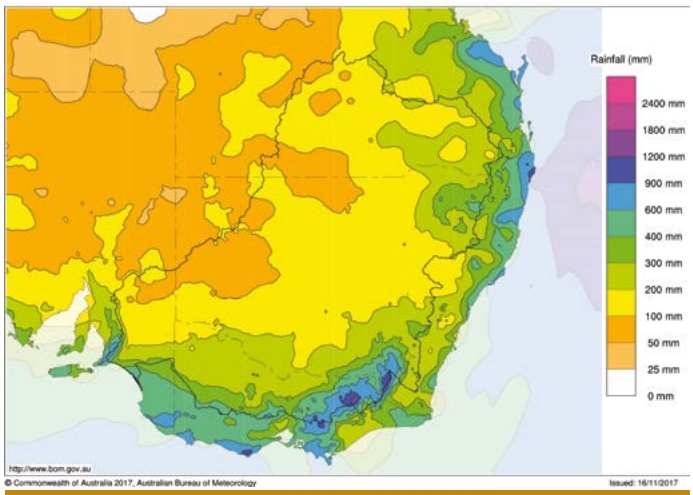
Those **lupins** that have been harvested have been crop-topped and have yielded around one tonne per hectare. But many lupin crops still have some green in them and are yet to be harvested. I expect lupin yields will be quite good for most growers.

The 2017 season delivered one of the worst early-season rainfall tallies but then had good rainfall through August and September. This has allowed crops to finish and give at least some yield. But most growers are looking forward to finishing harvest and putting a very challenging season behind them. Roll on 2018!

Peter Norris
Agronomy For Profit and Synergy Consulting, Geraldton
November 8, 2017

Southern region

Murray–Darling Basin rainfall totals (mm) April 1 – November 16, 2017
Australian Bureau of Meteorology



Patchy growing season rainfall since April have created a mixed bag of winter crops for the Murray-Darling Basin. Recent and widespread rainfall in northern NSW and Qld has lifted summer crop prospects in that region.

VICTORIAN MALLEE

Farmers in the Mallee are on the home straight with a sea of harvesters, chaser bins, field bins and trucks across the region busily stripping, loading and delivering grain.

There was no significant amount of rain during the late spring period reducing the requirement of regular disease management in the Mallee – this allowed for timely operations during spring.

Frost damage was isolated but severe throughout the Mallee.

District Reports...

Frost damage has been isolated, and to varying degrees. Damage has been particularly evident in cereal crops with paddocks (or isolated patches) of white heads, shrivelled grain and limited seeds forming in canola pods and/or pulse crops. Salvage options have included grazing and hay, where applicable.

Grain yields throughout the Mallee have been average to higher than average.

Those who had planned to grow crops for hay were rewarded with good quality. In light of a large amount of hay produced in 2016, albeit poor quality, prices have been low.

Mouse numbers remain moderate with reports of crop damage continuing despite monitoring and baiting. Damage is mainly evident through dead heads where the nodes have been chewed, or the entire head chewed off the plant.

There's a chance of average to above average rainfall throughout harvest so it's critical to remain vigilant and take measures during and after harvest to eliminate mouse food sources over summer. This will reduce the risk of an outbreak in autumn next year. Managing stubbles during this period will be another important task to reduce the level of mice breeding.

Grain farmers with a livestock component to their farm business will benefit from another year of high stubble loads for grazing over summer – particularly if there's grain/heads on the ground (get the sheep onto it before the mice!).

There has been no interruptive rain during harvest to date

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)	2017 rainfall to date (mm)	Summer		Autumn		Winter		Spring	
			25yr Annual Average (mm)	2016–17	25yr Annual Average (mm)	2017	25yr Annual Average (mm)	2017	25yr Annual Average (mm)	2017 to date
Emerald Qld	553	513	255	165	99	224	70	16	122	171
Toowoomba Qld	667	684	277	148	129	348	88	69	177	157
Roma Qld	574	464	254	179	113	183	78	40	131	112
Goondiwindi Qld	615	446	256	185	119	148	103	54	140	143
Narrabri NSW	628	496	226	145	112	231	130	73	165	75
Gunnedah NSW	638	507	224	186	106	138	129	74	181	104
Dubbo NSW	615	385	198	155	122	237	135	33	160	98
West Wyalong NSW	461	277	120	85	80	109	125	75	135	50
Wagga Wagga NSW	554	331	132	116	115	87	153	105	152	93
Swan Hill Vic	321	255	71	37	64	132	87	68	99	22
Bendigo Vic	514	428	108	102	106	187	160	124	143	45
Horsham Vic	379	359	77	86	71	120	122	114	108	71
Lake Bolac Vic	524	455	113	101	102	143	156	119	152	119
Murray Bridge SA	374	267	67	102	81	83	122	102	103	36
Kadina SA	347	238	56	165	82	43	114	71	91	47
Cummins SA	400	357	50	124	94	25	172	164	83	73
Esperance WA	622	610	80	203	146	108	250	219	143	107
Wagin WA	396	500	43	230	98	77	166	163	88	74
Northam WA	399	513	40	262	89	41	188	169	83	56
Mingenew WA	354	289	27	109	93	29	175	108	60	43
Moora WA	383	441	41	165	88	32	185	200	69	55
Mullewa WA	325	350	47	181	97	11	133	134	48	27

Last rainfall reading November 17, 2017.

District Reports...

November–December 2017

(November 14), but there is upwards of 10 mm forecast in coming days which will increase logistical pressure. Harvest must continue but so too does summer spraying if weeds emerge as a result of the pending rain. There's already reports of fleabane and melons emerging, and numbers will be heightened following rain.

Considering harvest goes well, most farmers in the Mallee will have parked the header in the shed prior to Christmas Day.

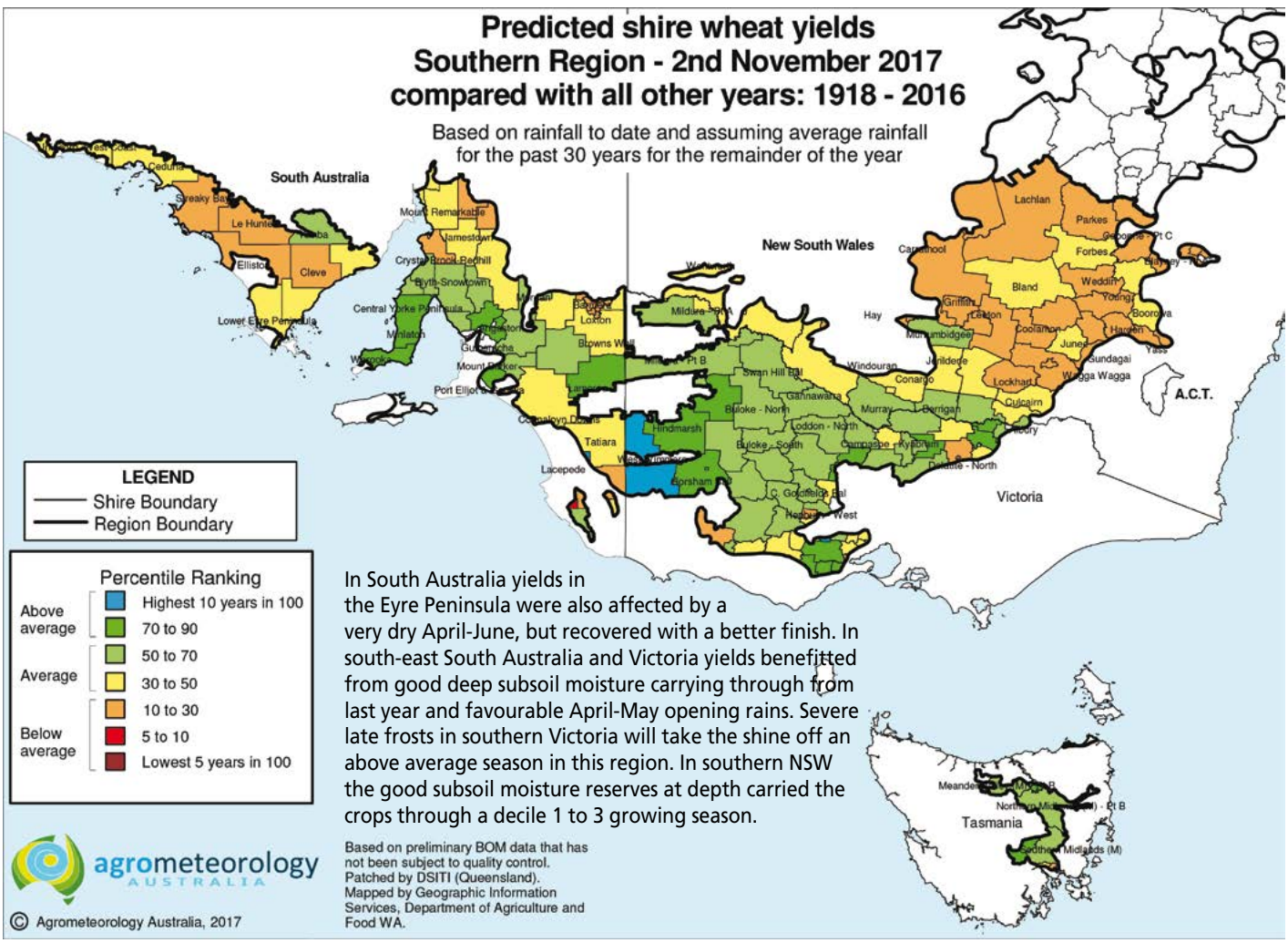
Ciara Cullen
BCG Extension Manager, Birchip
November 14, 2017

NSW OVERVIEW

The main points

- September was the driest on record for NSW, with rainfall below average across 92 per cent of the state. Large areas of the Riverina, south west and south coast recorded the lowest September rainfall on record. Areas of the central tablelands, Hunter valley, northern tablelands and north coast also received the lowest September rainfall on record.
- Only areas of the Murray valley, the north coast and limited areas of the far west received near-average rainfall during the April to September period.
- In most areas, potential winter crop yields were seriously affected by the combination of extremely dry conditions, frequent severe frosts and the extreme daytime temperatures during September. Where severely affected crops had sufficient biomass, they have been cut for hay and silage. In many cases crops have been grazed out to compensate for poor pasture production and to reduce the need for hand feeding of stock. Remaining crops will be carried through to harvest.
- Rainfall in early October came too late for most crops, with potential yields already severely affected. But the rain did benefit later maturing crops in areas of the south west slopes, the south east of the Murray valley and the eastern Riverina. The rainfall will allow for improved grain size in surviving crops in other areas as well.
- Harvest has commenced in the north west for canola and barley crops.
- Prospects for dryland summer cropping across much of the north west have improved due to rainfall of up to 25 to 100 mm in early October, with some areas receiving heavier falls. But more rainfall is needed to replenish depleted subsoil moisture reserves.

NSW Department of Primary Industries
Seasonal Conditions Report
October, 2017



Northern region

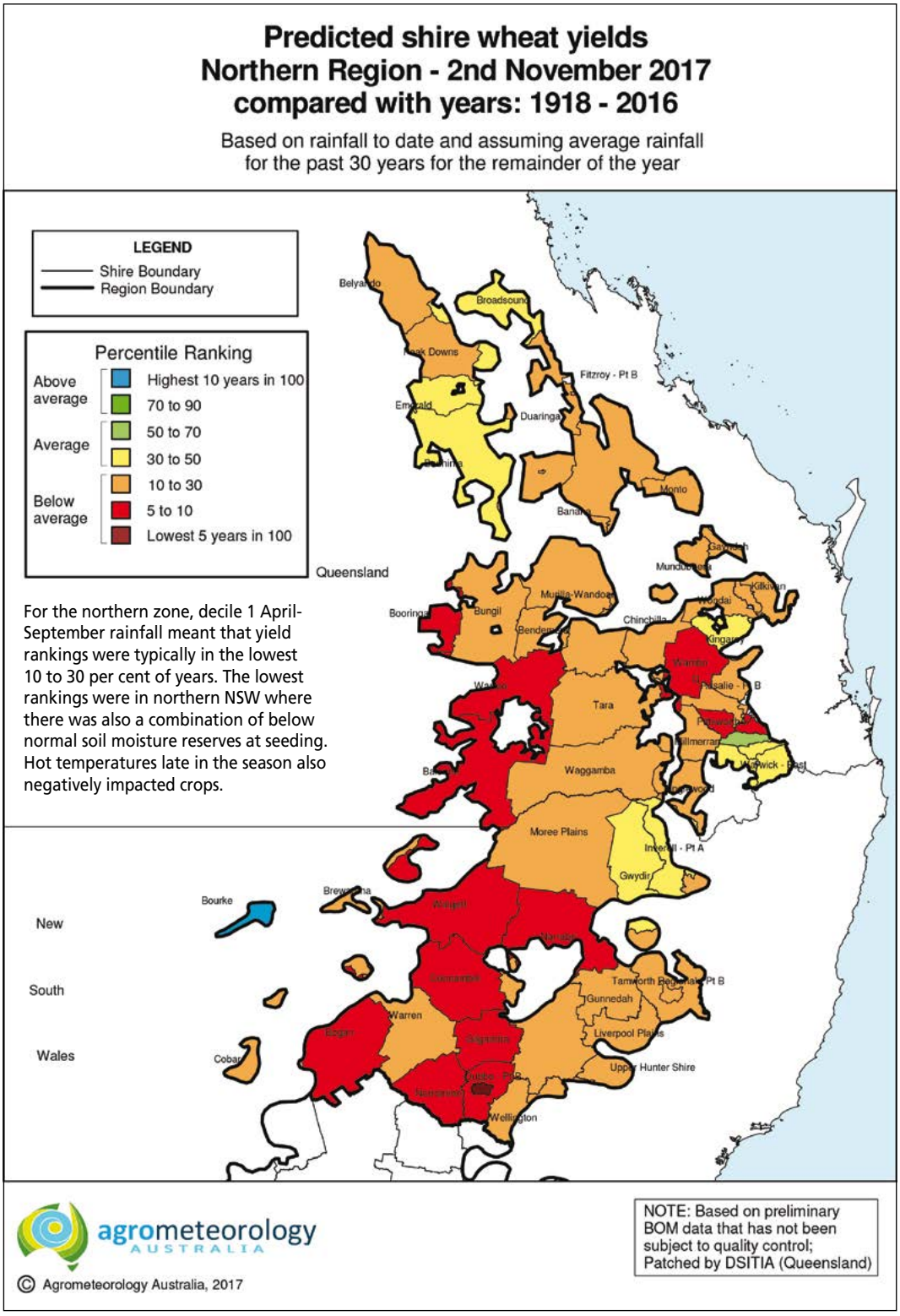
District Reports...

DARLING DOWNS

Weather conditions

Finally, in October, the rain arrived and most areas had between 50 to 150 mm, which has allowed a spring plant and made some improvement to the later planted winter crops.

November has started off with some showers, and unfortunately some hail, but the outlook for the summer season is a lot more positive now than two months ago.



2017 winter crop

Compared to last winter, this winter's yields will be very disappointing, with all crops affected both by the dry conditions and the frost damage.

The early planted cereal crops have been the most affected, having been hit hard after a good start, and being too far advanced to make use of the October rain. They have been yielding from under one tonne per hectare to two tonnes per hectare with issues, such as fusarium, pinched and shot grain, along with high screenings and lower protein wheat. But some of the later crops are producing 2–3.5 tonnes per hectare. Overall the harvest is still in the early stages, and growers are dessicating some crops because of the late flush of weeds in these thinner crops.

One of the main problems with the chickpea crops is their height, being so low that headers just cannot access all the pods. 30 per cent of the crops are still filling green pods, so harvest will be drawn out. The crop did suffer from frost damage through the season, and although the early heliothis infestations were effectively controlled, there is a heliothis build up in the later crops requiring further control. On top of that ascochyta is now starting to appear. Yields have ranged from under 0.5 tonnes per hectare to two tonnes per hectare, some with fair quality and other crops showing field fungi, especially after splitting.

Some of the storms have had hail, and there have been yield losses of 30 per cent from

District Reports...

hail and wind damage in areas. Hopefully the later sown crops will improve, but it has been a very tough winter for crop production.

2017–18 summer crop

The big increase in area of plantings has been sorghum, which is coming off a low base last summer. Improved prices have seen a 30 per cent increase in area so far, and the crops are emerging well with crops planted at the beginning of October already tillering. The spring plant of corn is reduced with many growers planning on a summer plant, even though gritting prices are stronger and there is good demand for silage corn. Weed control looks like being more of an issue this season, especially for the spring sown crops.

The overall cotton area will be fair, with irrigation areas up with water in farm storages, and dryland returning to its average area. Cotton emergence has been mostly good, although there is replanting where paddocks dried out too quickly.

A strong planting of corn and mungbeans in December and January is expected, especially if good rain continues to build soil moisture.

Hugh Reardon-Smith
Agronomist – Landmark, Pittsworth
November 9, 2017

The photo was taken in the Jondaryan area showing early and late sown chickpea crops beside each other, with a storm on the way. Rather typical of this winter!

ANSWER TO IAN'S MYSTERY TRACTOR QUIZ

The mystery tractor is a MacDonald Imperial, made in Melbourne and powered by a 40 hp single cylinder two stroke low compression diesel engine.

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