GRAINS RESEARCH UPDATE

STRATEGIC STEPS – ENDURING PROFIT

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Bute

Thursday 22nd February

9.00am to 1.00pm

Bute Sporting Club,

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Program

9:00 am	**Welcome**	***ORM***
9:00 am	**GRDC welcome**	***GRDC***
9.15 am	**Harvest weed seed control – advisers and growers spoilt for choice**	***Peter Newman,*** *AHRI & Planfarm Pty Ltd*
9.55 am	**Septoria tritici update and latest developments in powdery mildew managements**	***Nick Poole,*** *FAR Australia*
10.35 am	***Morning tea***	
11.05 am	**Hands Free Hectare (HFHa) – automated agriculture feasibility study**	***Martin Abell,*** *Precision Decisions Ltd*
11.45 pm	**Monitoring mice in Australia**	***Steve Henry,*** *CSIRO*
12.25 pm	**Herbicide and weed management - latest research**	***Chris Preston,*** *The Univeristy of Adelaide*
1.05 pm	***Close and evaluation***	***ORM***
1.10 pm	***Lunch***	

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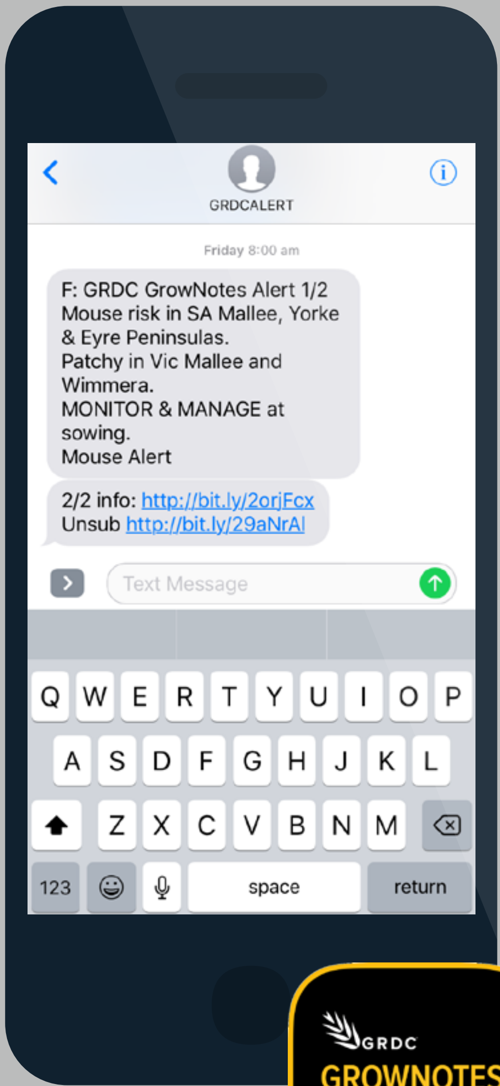

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GRDC GROWNOTES ALERT

Harvest weed seed control – growers spoilt for choice

Greg Condon[1,2] and Kirrily Condon[1,2].

[1]Grassroots Agronomy; [2]Australian Herbicide Resistance Initiative.

Keywords

- weed seed banks, integrated weed management (IWM), herbicide resistance, annual ryegrass, wild radish, harvest weed seed control (HWSC), narrow windrow burning (NWB), chaff cart, chaff lining, chaff decks, Integrated Harrington Seed Destructor (iHSD).

Take home messages

- Harvest weed seed control (HWSC) comes in many forms — bale, burn, graze, mill or rot.
- Match the HWSC tactic to your farming system, crop types and location.
- Capturing weed seeds in the chaff fraction when chaff lining or using chaff decks requires attention to detail in harvester set-up.
- HWSC cannot be used effectively in isolation — adopt the 'Big six' and top shelf agronomy to drive weed numbers to zero.

Background

Grain producers have become more proficient atHerbicide resistance remains an ongoing challenge for Australian grain growers, but the industry is continually innovating to minimise the risks. Non-chemical tools are becoming mainstream practice so that growers and advisers can deal with herbicide resistance by reducing weed seed banks and protecting chemistry.

One of the most popular weed management tactics being adopted in recent years is harvest weed seed control (HWSC). This process takes advantage of seed retention at maturity by collecting weed seeds as they pass through the harvester. Problematic weeds such as annual ryegrass, brome grass and wild radish retain 77% to 95% of their seed above a harvest cut height of 15cm at maturity, creating an ideal opportunity for seed collection.

Seed retention will change over time with the proportion of retained weed seeds declining the longer harvest is delayed past crop maturity. Therefore, crop and weed maturity will have a significant impact on the success of HWSC. Harvest height is equally important for HWSC, with a 15cm cut height preferred to capture 80% to 90% of the ryegrass seed at maturity — this can be challenging in high yielding cereals or bulky hybrid canola crops.

In the southern cropping region, low harvest height has been a barrier to adoption with growers not wanting to slow harvest down, incurring higher fuel costs and reducing harvester efficiency. Growers and researchers have since been looking at tactics that will enhance the efficacy of HWSC without slowing harvest. One option being adopted is sowing crops at narrower row spacings or higher plant populations. Weeds are then forced to grow taller to compete for light, therefore producing seed higher in the crop canopy. Stripper fronts are also being investigated to gauge any differences with weed seed capture and harvest efficiency, reducing the need to cut low whilst minimising fuel consumption.

HWSC practices

Originally pioneered 30 years ago with chaff carts in Western Australia (WA), HWSC has now been adopted nationally as growers tailor their options to suit different farming systems and locations.

The HWSC options are all slightly different with narrow windrow burning (NWB) and bale direct taking in both straw and chaff for burning or baling. Newer HWSC practices only take in the chaff fraction containing weed seeds for rotting, grazing or destruction through a mill. This includes chaff lining or chaff decks, chaff carts and emerging mill technology using the Integrated Harrington Seed Destructor (iHSD) or Seed Terminator.

Research by Walsh et. al. 2014 (https://ahri.uwa.edu.au/harvest-weed-seed-control-tools-they-all-work/) highlighted that HWSC tactics are equally effective in reducing weed seed production. The use of chaff carts, NWB or iHSD, were compared at 24 sites across Australia with an average reduction in ryegrass of 60% germination the following autumn. This was achieved by removing 70% to 80% of the seed at harvest through either burning or destruction of weed seeds.

Research has recently commenced to gauge the impacts of chaff lining and chaff decks on the rotting of weed seeds under different crop types. Preliminary data suggests poor seed survival under canola or barley chaff because of an allelopathic effect, however, in wheat there was high ryegrass seed survival underneath the chaff row which is unexplained. Michael Walsh from Sydney University and John Broster from Charles Sturt University are currently working to quantify the value of rotting under chaff line and chaff deck systems.

Each HWSC practice has its own benefits and challenges with growers leading the charge, working with a small group of researchers to develop harvester modifications that maximise weed seed control with harvest height and seed retention. For HWSC to be successful at the farm level, the practice needs to be both cost effective and practical to fit in with existing operations.

HWSC cannot be used in isolation for weed management — growers and advisers should implement a range of diverse weed management practices to drive weed numbers down. Defined as the 'Big six' (https://weedsmart.org.au/the-big-6/), these management practices include diverse rotations, mix and rotating herbicides, crop competition, double knocks, crop topping/hay to stop seed set and HWSC. The 'Big six' complements best practice agronomy such as calendar sowing combined with effective pre-emergent herbicide packages.

HWSC adoption

An online twitter survey was conducted in November 2017 by WeedSmart with 269 growers responding. The results indicated that HWSC practices are changing, with NWB declining at the expense of chaff lining and chaff decks. Thirty two percent of growers were planning to use NWB in 2017, whilst 26% would be chaff lining and 9% using chaff decks. Chaff carts were stable at 13%, mill technology at 3% and 14% would be doing nothing.

The overall trend is positive and reflects the high value growers are increasingly putting on HWSC as a mainstream weed management tool. It does not come easy and looking at each practice in detail (Table 1) highlights what growers and advisers need to be aware of.

Table 1. HWSC options.

HWSC tactic	Indicative cost	Labour required	Crop residue removed	Positives	Negatives	Best fit
NWB	$200	Burning rows	Chaff and straw 40%-100%	Low cost	Nutrient removal, smoke, fire escapes	Low rainfall, canola and pulses
Glenvar Bale Direct	$340,000	Pick up bales	Chaff and straw 40%-50%	Profit from bales	Nutrient removal, cost	Market for bales
Chaff carts	$15,000 to $80,000	Graze, burn heaps	Chaff only 15%	Feed value for sheep	Burning of piles	Mixed growers
Chaff lining	$200 to $4500	Minimal	Chaff only 15%	Low cost, no burning, weed seeds left to rot	Insects and mice in chaff rows	Everywhere except small, windy paddocks. Suits both mixed growers and intensive croppers
Chaff decks	$15,000 to $20,000	Minimal	Chaff only 15%	No dust on tramlines, no burning	Insects and mice in chaff rows, chaff rows driven over	CTF growers, both mixed and intensive croppers
iHSD	$165,000	Minimal	0%	No loss of residue	Still in the development stages, cost	Intensive croppers
Seed Terminator	$100,000	Minimal	0%	No loss of residue	Still in the development stages, cost	Intensive croppers

Narrow windrow burning (NWB)

Developed in the northern WA cropping zone, NWB has been highly effective at reducing annual ryegrass and wild radish seed banks across the nation. A chute is attached to the back of the harvester to concentrate straw and chaff into a 500mm to 600mm narrow windrow — these rows are then burnt the following autumn. The practice is low cost and highly effective with rows burning hotter for longer than a standard stubble burn. Up to 99% of weed seeds are controlled in a well managed hot burn where temperatures reach 400°C to 500°C for at least 10 seconds.

Despite its simplicity and popularity, the practice is now in decline due to several factors. Burning is the major challenge, especially if fire escapes from the rows to burn the whole paddock or trees. Rows becoming wet after summer rains can create challenges waiting for the rows to dry out for the fire to burn hot enough and destroy weed seeds. Nutrient redistribution and ground cover loss are also key issues for growers using NWB, particularly on lighter soil types.

Smoke in built up rural communities has been problematic for NWB, where smoke lingers late into the evening when wind inversions occur. Some growers are actively looking at alternative options to NWB, whilst for those where the process works, it will remain a key tool in their HWSC toolbox.

Glenvar Bale Direct

Chaff and straw are collected during harvest then baled directly using a baler attached to the harvester. There is a moderate level of ground cover removal with straw and chaff removed, whilst weed seed removal is high. A large capacity harvester is needed to operate the baler, but does not slow the harvesting operation down. Growers would require access to markets to utilise the bales for bedding or as a feed source.

Chaff carts

The first HWSC tool was introduced from Canada for the collection of chaff material for feeding to sheep. A cart is towed by the header which collects chaff and weed seeds then dumps it in piles for grazing or burning. The original blower delivery system was improved with a conveyor belt elevator which allows some small straw into the chaff fraction. The increased oxygen levels in the chaff have resulted in a quicker, hotter burn. Burning of chaff piles has created similar issues to NWB with chaff piles smouldering for long periods.

New research is proving the value of chaff dumps, not only for weed seed reduction, but also sheep feed (https://ahri.uwa.edu.au/chaff-carts-good-for-the-crop-and-the-sheep/). Chaff piles can be grazed by sheep directly or baled for sale into feedlots or other associated markets. Ed Riggall is a sheep consultant from WA who has found that sheep grazing chaff piles gained 3kg/head more over three weeks than those without chaff piles. This was despite the sheep taking one week to get used to the chaff piles. Chaff piles are reducing supplementary feeding costs and increasing scanning results while reducing weed seed numbers. Studies have shown that sheep do not spread weed seeds, with only 3% to 6% of seed remaining viable after passing through the rumen. Cattle are less effective at destroying ryegrass seed with 15% to 20% of the seed remaining viable.

Chaff lining

Developed by Esperance grain growers, chaff lining involves separation of the chaff and weed seed fraction from the straw residue, with chaff dropped into a narrow line behind the harvester via a chute attached to the main sieve. The chaff line remains on the soil surface where weed seeds are left to rot, while the straw travels through the rotor to be chopped and spread.

Chaff lining is repeated on the same runs year after year to allow weeds to continually rot in a defined area. There is limited research data to quantify the full impacts of seed rotting, but observations to date indicate the undisturbed chaff row is a hostile environment for weed seeds. Growers do not need to be on a full controlled traffic farming (CTF) system, but ideally the header needs to run on the same lines each year.

Chaff lining is low cost, involves no burning and growers have the option to graze chaff lines with similar feed values as those found with chaff carts. Chaff lines have been successfully grazed in stubble over summer, but also in winter when sown to a dual-purpose grazing crop.

Harvester set-up is critical to maximise weed seed capture with growers adding a separating baffle above the sieves to ensure chaff stays out of the straw and exits via the chute. Grain needs to be threshed hard to remove weed seeds out of the head, with the grates of the harvester opened up to get as much material out of the rotor and onto the sieve for collection.

Growers have built their own chutes and baffles to suit a wide range of harvesters with 2017 being the first season many growers adopted the practice. There were several situations where chaff lining set-ups caused issues at harvest including a build up of excess fine chaff on the air cleaner or blockages at the rear of the baffle in canola. Refinements to chaff lining are ongoing as growers work with each other and industry to achieve continuous improvement with the practice.

Chaff decks

The chaff deck system operates on a similar principle to chaff lining, but the chaff material is directed onto dedicated wheel tracks in a CTF system. Known also as chaff tramlining and developed in the Esperance region of WA, weed seeds exit the harvester off the sieves in the chaff fraction whilst straw is chopped and spread with no loss of harvest efficiency. Weed seeds are exposed to the same rotting effects as in chaff lining, but there is half the material given the split across the two wheel tracks.

Dust generated when summer spraying is minimised due to the presence of the chaff on the tramlines. Conversely, the weed seeds are exposed to a level of disturbance on tramlines which increases their potential to germinate as opposed to continually rotting. This contrasts with chaff lining where the single chaff row is not exposed to any wheel traffic and potentially optimises its rotting potential.

Chaff deck systems have opened new opportunities for alternative forms of weed control not previously thought possible. Weed seed collection has been so effective that very dense populations have emerged in defined rows on the tramlines in crop. Due to the nature of permanent CTF tramlines, growers can use a range of alternative chemistry or cultural practices throughout the season and not affect the main crop. For example, in a 12m CTF system only 8% of the paddock is dedicated to wheel traffic, therefore weeds in the chaff lines can be targeted using non-chemical options such as microwave, baling or crimping as potential forms of site specific weed control.

Agronomy for chaff rows created by chaff decks and chaff lining is a key issue and growers need to be aware of some issues that need to be managed. These include:

- Sow through the chaff rows with either a disc or tyne — unsown rows become too weedy without any competition. Increase the sowing rate on these rows if practical.
- Increase herbicide rates on the chaff rows using higher output nozzles for all passes including knockdown, pre-emergent, post emergent and crop topping.
- Graze with sheep where available to help to reduce the bulk of chaff rows.
- Monitor for pests such as mice, earwigs, millipedes and slaters, which can breed up in chaff rows, especially when sowing canola and consider on-row baiting or insecticide.

Integrated Harrington Seed Destructor (iHSD)

Recognised as the ultimate form of HWSC, the mill technology conceived by Ray Harrington is now reaching commercial reality for growers with investment from GRDC. The iHSD comprises of two hydraulically driven cage mills that are mounted within the back of the harvester (just below the sieves). The mills can destroy 93% to 99% of the weed seeds and then spread the material back out on the paddock without any loss of stubble or nutrients. Suitable for fitting onto all class eight, nine and ten harvesters, the mill has been tested to destroy 96% of annual ryegrass seeds, 99% of wild oat seeds, 99% of wild radish seeds and 98% of brome grass seeds in the chaff.

Seed Terminator

Developed by Nick Berry and his group in South Australia (SA), the Seed Terminator uses a multi stage hammer mill on weed seeds in the chaff fraction. The mill uses a combination of processes to shear, crush, grind and high impact to destroy more than 90% of weed seeds. More research is underway to further quantify this weed seed kill. The mill is mechanically driven with three stages of screen to sort material for size and can be operated at dual speeds of 2800 and 2950 RPM.

Conclusion

Growers now have available a diverse range of HWSC tactics at their disposal depending on their farming system, location and scale. The options are becoming less labour intensive with a shift away from burning of windrows towards chaff lining or mill technology, which leave crop residues and nutrients in place. Although intensive croppers have previously been the major adopters of HWSC, mixed growers can also benefit through grazing chaff dumps or chaff lines while reducing weed seed banks.

HWSC is part of a broader weed management package that includes improved herbicide management as well as crop competition, diverse rotations, double knocking and crop-topping or hay to stop seed set. The implementation of some or all these tactics will ensure growers keep weed seed banks low, but more importantly, remain profitable.

Useful resources

Broster J, et al. (2015). Harvest weed seed control: ryegrass levels in south-eastern Australia wheat crops. 17th Australian Agronomy Conference. http://agronomyaustraliaproceedings.org/images/sampledata/ASA17ConferenceProceedings2015.pdf

Walsh M, et al. (2017). High levels of adoption indicate that harvest weed seed control is now an established weed control practice in Australian cropping. Weed Science Journal of America 31, 341-347.

https://ahri.uwa.edu.au/harvest-weed-seed-control-tools-they-all-work/

https://ahri.uwa.edu.au/chaff-carts-good-for-the-crop-and-the-sheep/

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Notes

Septoria tritici update and latest developments in powdery mildew management

Nick Poole and Tracey Wylie.

FAR Australia.

ΦExtra technical comment by Protech Consulting Pty Ltd

GRDC project codes: FAR00004-a, FAR00002 and CCDM Programme 9

Keywords

- Septoria tritici blotch (STB) *Zymoseptoria tritici*, powdery mildew *Blumeria graminis f. sp. tritici*, fungicide resistance, integrated disease management (IDM), Quinone outside Inhibitors (QoIs), strobilurins, triazoles.

Take home messages

- Reduced sensitivity of the septoria tritici blotch (STB) pathogen *Zymoseptoria tritici* to triazole fungicides is likely to be an increasing problem, following the discovery of more resistant biotypes (R8 strain or Isoform 11) on the mainland in 2016.
- The presence of this strain and its proportion in the population will influence disease management strategies differentially.
- In Tasmania, early season disease control in the field with flutriafol (2017 trials) and tebuconazole (2016 trials) has been reduced by more resistant biotypes of the pathogen (R8 strain or Isoform 11), whilst on the mainland, STB activity of flutriafol appears to have been maintained in 2017.
- The performance of a new Succinate Dehydrogenase Inhibitor (SDHI) based seed treatment and to a lesser extent fluquinconazole (Jockey®) has been better than flutriafol in Tasmanian trials.
- Following the discovery of wheat powdery mildew (WPM) resistant to strobilurin fungicides in 2016 and 2017 collectively, we should aim to minimise the use of fungicides containing QoIs to one per season.
- Use integrated disease management (IDM) measures such as more resistant cultivars, rotating out of wheat where wheat stubbles were infected with WPM in 2016 and removing the green bridge volunteers to further prevent infection.
- Where more than one fungicide is used in wheat, avoid using the same triazole active ingredient twice, irrespective of diseases to be controlled.

Background

Septoria tritici blotch (STB) continued to be a problem in 2017 despite the drier conditions encountered compared to 2016. This was likely the result of stubble infection from 2016 and cultivar susceptibility. Whilst the adoption of integrated disease management (IDM) remains central to prolonging the activity of fungicides, 2017 research results illustrated geographic region was a key consideration in the adoption of fungicide management strategies. In Tasmania, where the use of fungicides is more intensive as a result of a longer more disease prone season, the field performance of commonly used fungicides, such as flutriafol and tebuconazole, is being compromised by more resistant strains of the STB pathogen. These more resistant strains show reduced sensitivity to fungicide applied in the field, meaning that although they still give some control, they are not as effective as they once were. It was confirmed at the 2017 Wagga Wagga GRDC Grains Research Updates that the more resistant strains found in Tasmania are now being found on the mainland at low levels in the population. As a result, FAR Australia, working with Southern Farming Systems and Mackillop Farm Management Group, has been evaluating the performance of these fungicides on both the mainland and in Tasmania. This paper builds on the paper presented at the 2017 GRDC Updates looking at the 2017 results from the GRDC funded project FAR00004-a that was set up to look at the control of STB and leaf rust in the field.

For the first time in 2016, wheat powdery mildew (WPM) samples from both southern Victoria and Tasmania were confirmed as being resistant to QoI fungicides (FRAC Group 11) commonly referred to as the strobilurins e.g. azoxystrobin, pyraclostrobin. At present, it is difficult to comment on how widespread these resistant mutations are within the mildew population, however it is the same mutation that was found in Europe and New Zealand (G143A mutation). In this paper, we look at the consequences of this resistance mutation spreading in the WPM pathogen population.

Research conducted on STB in 2017

Field research was conducted at four sites in the 2017 season: Hesse and Westmere in southern Victoria, Hagley in Tasmania and Conmurra in south east South Australia. In contrast to 2016, growing season rainfall (April-November) for 2017 was lower in all of these regions, a factor which would have restricted the ability of the disease to be as damaging.

Table 1. Growing season rainfall at the research locations where control of STB is being assessed.

Trial site region	2016	2017
Hesse, Victoria	430	379
Hagley, Tasmania	827	430
Conmurra, South Australia	675	476
Westmere, Victoria	561	436

At the time of writing this paper, 2017 harvest data was in the process of being analysed or trials were not yet ready for harvest (Tasmania), therefore the following paper is primarily based on disease data collected from the FAR Disease Management Centre at Hesse in southern Victoria, where yield data was available.

Results and discussion

Fungicide performance against STB - Zymoseptoria tritici

Influence of at 'sowing' fungicide products on the mainland and in Tasmania

Work in southern Victoria, where STB has been problematic since 2010, has shown that flutriafol applied in furrow is still giving relatively good control despite the discovery of STB strains that reduce the performance of flutriafol. Results at FAR Australia's Disease Management Centre in 2016 and 2017 revealed field control from flutriafol was similar (or superior, data not shown) to fluquinconazole (Jockey®)$^{\Phi}$ (Figure 1).

$^{\Phi}$ *Registered for suppression not control.*

At present, it is thought that the level of the R8 strain or isoform 11 strain (the strain that carries one of the more serious mutations for reduced sensitivity to triazoles) is at relatively low levels in the mainland population of STB. This may help explain why flutriafol's field performance still appears reasonably good. However, assuming that this strain of the disease is equally fit (adapted to the environment) as other strains of the STB pathogen, it is likely that this strain will increase in importance and as a result increasingly reduce the efficacy of triazole fungicides, in particular flutriafol and tebuconazole. This is what looks to have happened in Tasmania where the frequency of the R8 or Isoform 11 strain in the STB population is much higher than it is on the mainland. This strain in Tasmania is at such high levels in the population that the performance of triazoles in the field is now being compromised. However, the reduction in the performance of triazoles is not occurring equally. In trial data, flutriafol and tebuconazole are affected to a greater extent than other triazoles, such as the seed

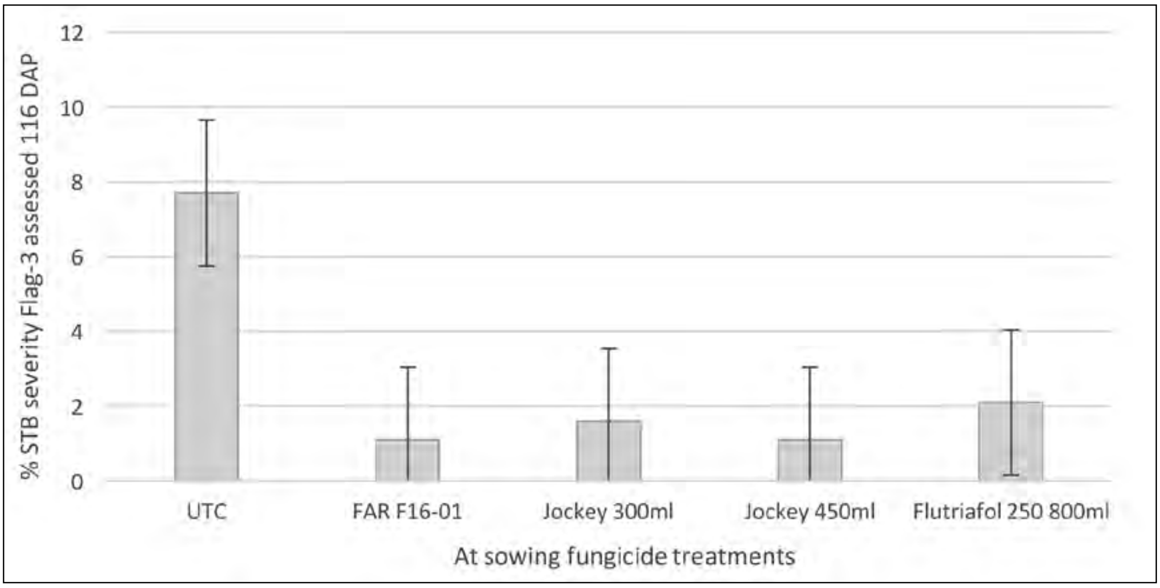

Figure 1. Influence of 'at sowing' fungicide applications on % STB infection recorded on F-3 at GS37-39 on 31 August 116 days after planting – cv Bolac⁽ᴰ⁾, Gnarwarre, southern Victoria 2016 FAR F16-01 (Experimental seed treatment), Jockey® 300mL$^{\Phi}$ (/100kg of seed), Flutriafol 250 800ml/ha (applied to MAP).

$^{\Phi}$ This is below the label rate of 450mL/100kg.

treatment fluquinconazole (Jockey®) or the foliar applied triazole epoxiconazole (Opus®). Fungicides with an alternative mode of action, such as the SDHI seed treatment FAR F17-01, are also unaffected by this mutant strain and have performed extremely well in 2017 at the Tasmanian site (Figure 2).

It should be emphasised that the fungicide products tested are all approved for use in wheat$^{\Phi}$ and were tested for control of STB and leaf rust that occurred together in this experimentation. It should also be emphasised that not all products tested have an individual label recommendation for STB control, even though they are all approved for use in wheat. The infection of leaf rust was not noted to be as severe in 2017 and therefore is unlikely to have influenced the yield results to the same extent as it did in 2016.

$^{\Phi}$ All products tested except FAR F16-01

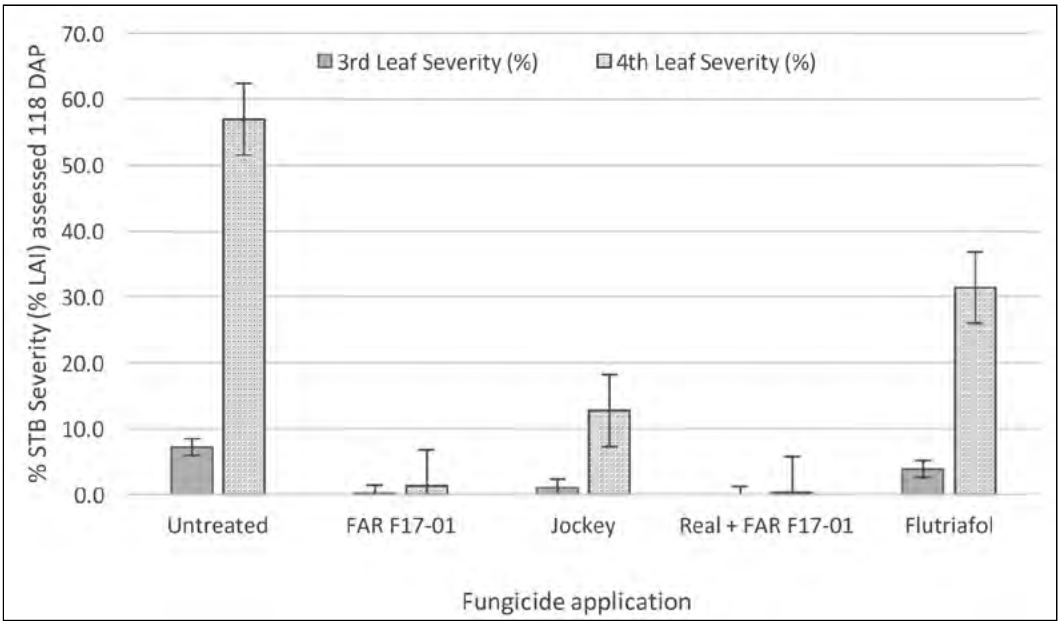

Figure 2. Influence of 'at sowing' fungicide applications and Opus® 500mL/ha applied at GS24 on % STB infection severity recorded on third and fourth oldest leaf at the late tillering stage (GS25) on 23 August 118 days after planting – cv SQP Revenue⁽ᴰ⁾, Hagley, Tasmania.

Overall, from the trial locations where testing is taking place, it would appear that disease management strategies in Tasmania need to be modified to take account of changes that have already occurred in the STB pathogen population. However, on the mainland if the proportion of more resistant isolates increases, then changes in disease management strategies will be forced upon growers and advisers as some active ingredients become less effective. For now though, whilst we are not seeing the effects of changes in the STB population to the same degree on the mainland, it is important that we collectively act by adopting as many IDM options as possible before resorting to fungicide use and wherever possible, alternating our fungicide strategies so we do not depend on the same active ingredients.

Foliar fungicide performance against STB

The significant differences in product performance resembled results generated in 2016 under higher disease pressure with triazole and strobilurin mixtures (Radial®, Amistar Xtra® based on the strobilurin azoxystrobin) and SDHIs performing more strongly than some of the triazoles applied alone. Of the triazoles used in wheat, Opus 125 SC® (epoxiconazole) and Prosaro 420 SC® (tebuconazole and prothioconazole) were significantly superior to tebuconazole and the coded triazole FAR F1-16. In terms of yield response, all fungicides applied at their full rate gave a significant yield response, however there were no significant yield advantages to the strobilurin and SDHI triazole mixtures over Opus® and Prosaro® in 2017 as there had been in 2016 when both yields and disease pressure were higher.

It should be emphasised that although Opus® and Prosaro® are approved for use in wheat, there is currently no label recommendation for STB control.

Integrated Disease Management (IDM) - influence of cultivar resistance on fungicide strategy

Adopting better genetic resistance is a key strategy for reducing STB infection in wheat and reducing the exposure of fungicides to the further development of pathogen resistance. 2017 results from GRDC project FAR00004-A illustrated the positive impact of genetic resistance on disease management strategies. Beaufort⫛ (rated susceptible STB), Accroc (moderately susceptible STB) and SQP Revenue⫛ (moderately susceptible STB) were evaluated with nine different levels of fungicide management. The results illustrated that Accroc and Revenue⫛ significantly reduced disease

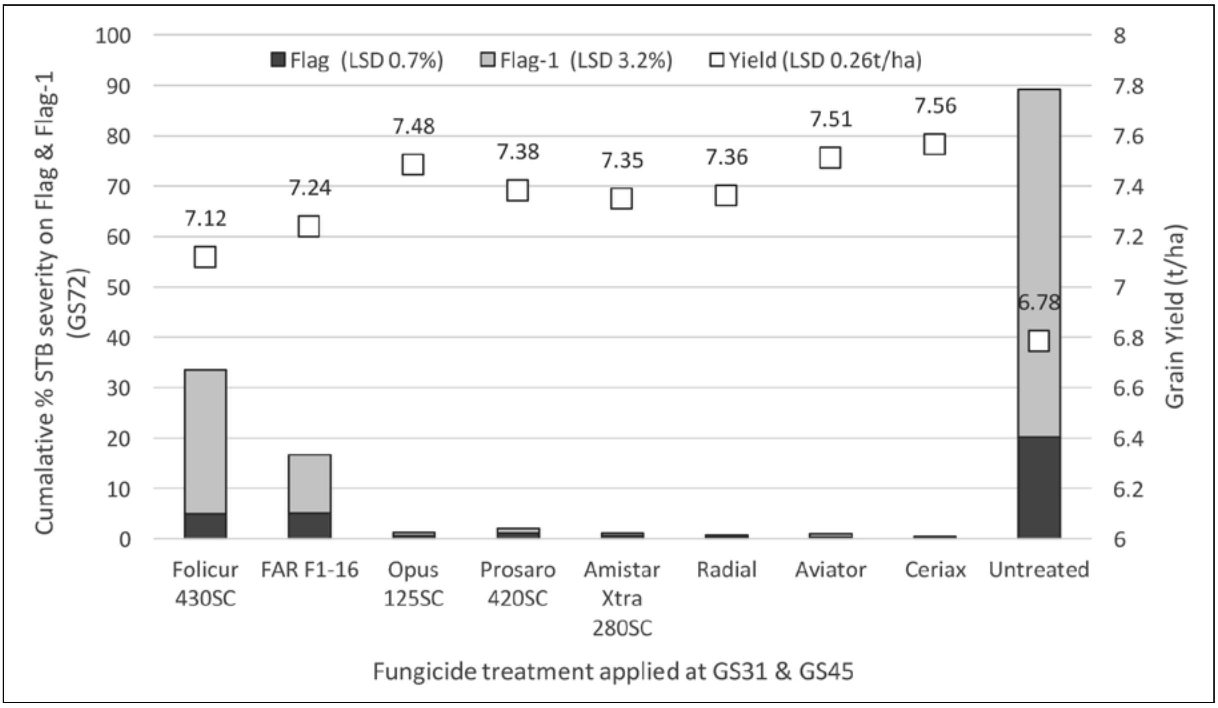

Figure 3. Influence of foliar fungicides (full label rate) on STB % severity and yield (t/ha) of wheat – cv SQP Revenue⫛, FAR Disease Management Centre, Hesse, Southern Victoria.

Φ Of the products listed in Figure 3 the only Aviator product registered is Aviator XPro and it is not registered in wheat. Ceriax is not registered and Folicur is no longer registered. These products are used for research purposes only.

pressure in relation to Beaufort⁽ᵈ⁾ and produced no significant differences in STB infection whether one, two and three spray fungicide programs were applied (Figure 3). However, with Beaufort⁽ᵈ⁾ under higher disease pressure, increasing the number of foliar fungicides progressively reduced STB infection in the lower canopy, particularly with the GS31 and GS39 sprays. With Accroc and SQP Revenue⁽ᵈ⁾ the slight improvement in genetic resistance resulted in lower disease pressure and no significant differences in disease control between one, two and three spray fungicide programs, whilst with Beaufort⁽ᵈ⁾ there was a clear advantage in the lower and upper canopy disease control between one and two spray programs.

With the slightly more resistant cultivars SQP Revenue⁽ᵈ⁾ and Accroc, there was an indication that disease development was delayed compared to Beaufort⁽ᵈ⁾ and that severity increased later in the season, since there were significant advantages to two sprays over one on Flag-1 at the later assessment taken on 17 November during grain fill (data not shown). The increased STB genetic resistance of SQP Revenue⁽ᵈ⁾ and Accroc over Beaufort⁽ᵈ⁾ was manifest in the yield responses obtained in the trial (Figure 5). The level of yield response in Accroc and SQP Revenue⁽ᵈ⁾ was approximately half of that observed in Beaufort⁽ᵈ⁾, however all three cultivars gave the optimum economic response from two fungicide applications applied at GS31 (1st node) and GS39-45 (flag leaf emergence - booting). In part this result is thought to be related to rainfall events favourable for STB infection in September that occurred after the first fungicide was applied on 10 September and before the second spray was applied on 3 October (Figure 6).

Fungicide activity against powdery mildew and strobilurin resistance

Product performance against powdery mildew – Blumeria graminis

Early in 2017, researchers at the Centre for Crop and Disease Management (CCDM) led by Dr Fran Lopez discovered strobilurin (Quinone outside Inhibitors (QoI) – FRAC Group 11) resistance in wheat powdery mildew (WPM) *Blumeria graminis f. sp. tritici*. The resistance was discovered in samples from susceptible cultivars grown in southern Victoria and Tasmania. This was the first case of QoI resistance in broadacre cereal crops in Australia. The single point mutation that confers this resistance (G143A mutation) is exactly the same mutation that exists in the WPM resistant populations in Europe, discovered two years after these products were introduced in 1996. It is a single step to resistance and means that QoI or strobilurins, irrespective of active ingredient, will not give control. In Australia, the greatest of the unknowns is how prevalent this mutant is in the pathogen populations in these regions. At present, this resistance has not been

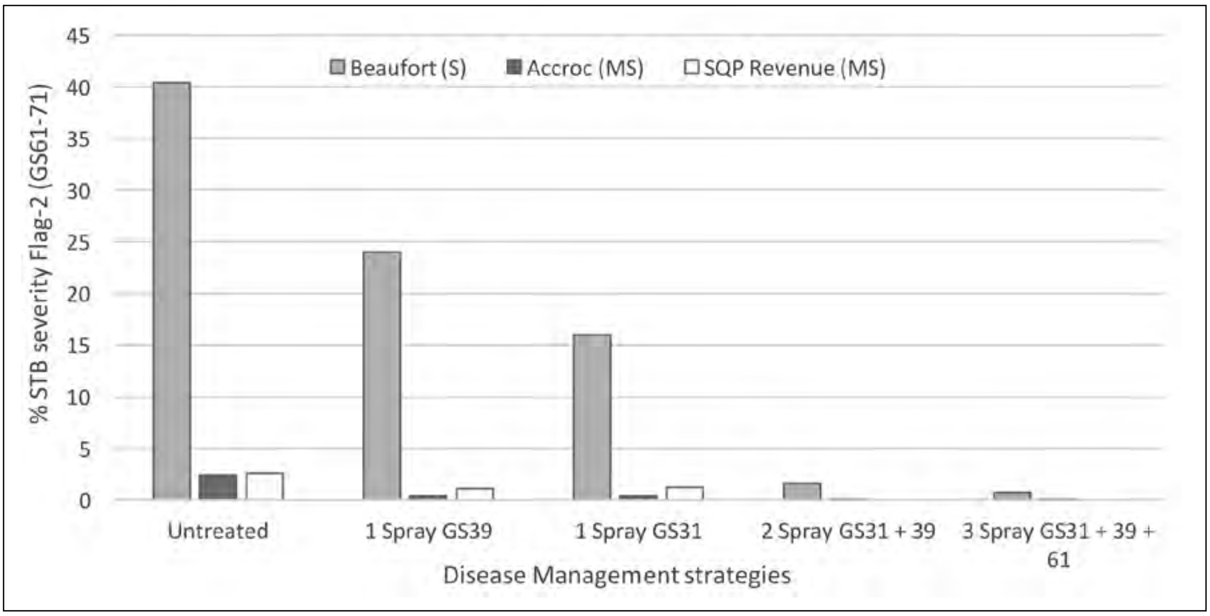

Figure 4. Influence of cultivar resistance and number of foliar fungicides on % STB infection on the lower crop canopy (Flag-2) assessed at flowering (GS61-71 3 November) – FAR Disease Management Centre, Hesse, Southern Victoria.

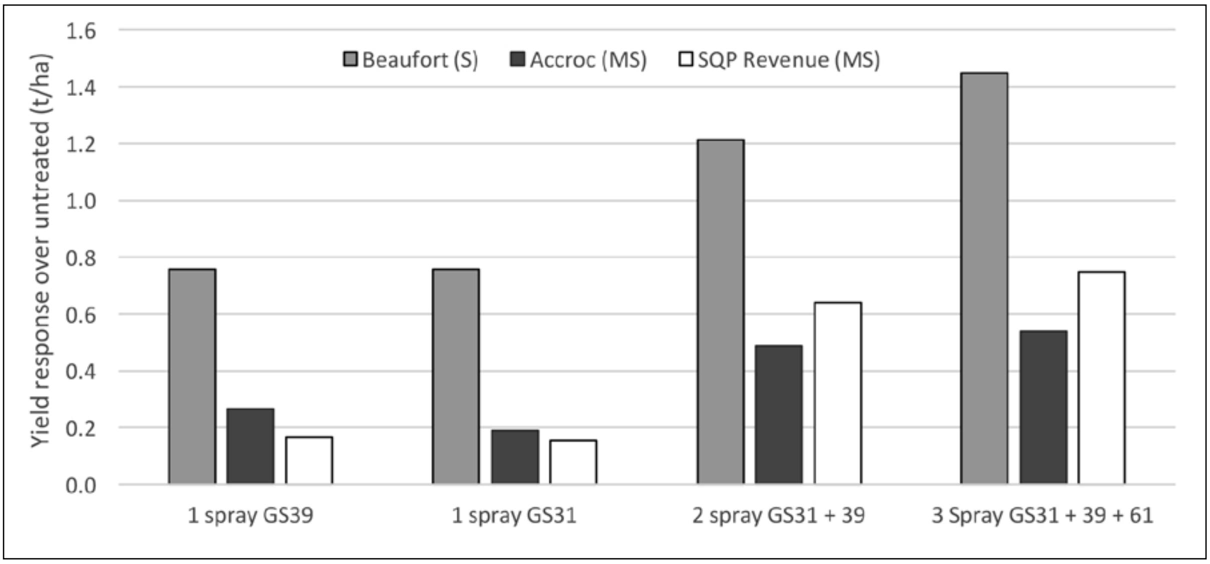

Figure 5. Influence of cultivar resistance and number of foliar fungicides on yield response (t/ha) in three cultivars (Beaufort⁽ᵈ⁾, Accroc and SQP Revenue⁽ᵈ⁾) of differing disease resistance – FAR Disease Management Centre, Hesse, Southern Victoria.

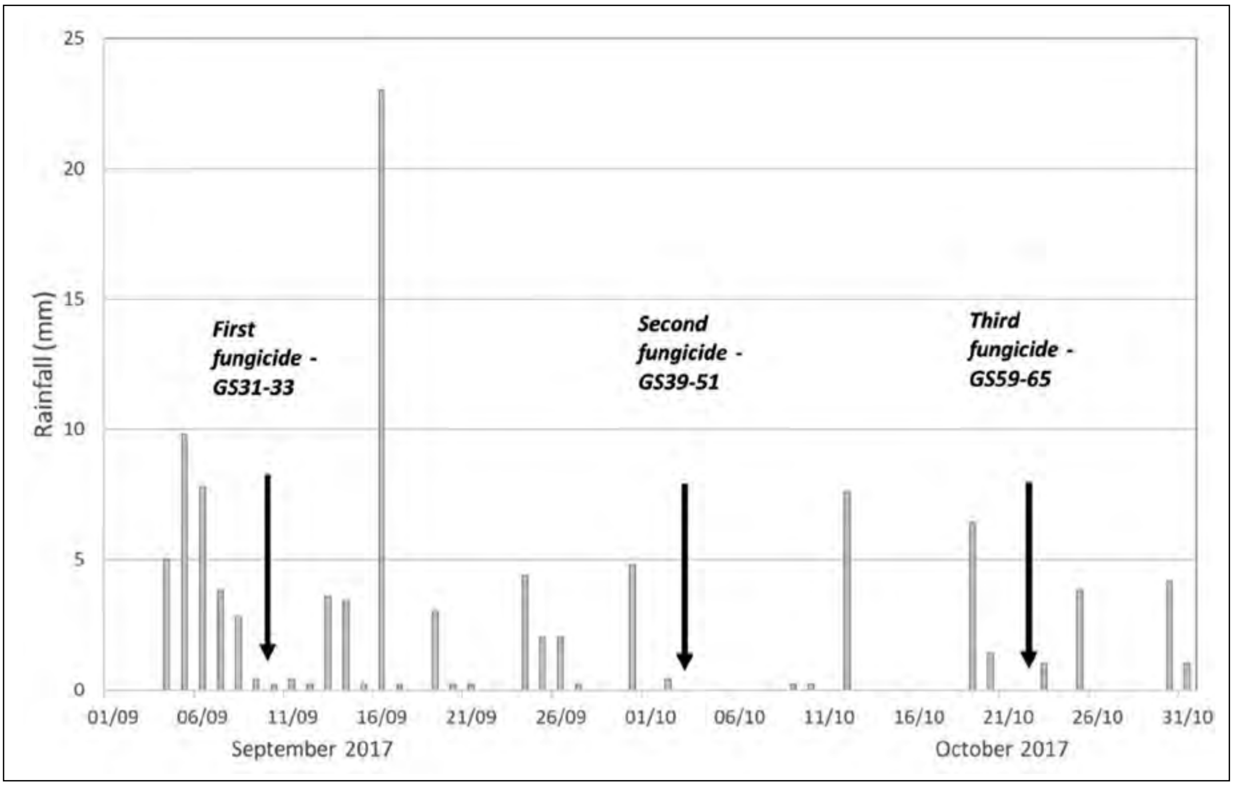

Figure 6. September and October rainfall in relation to fungicide application and development stage – FAR Disease Management Centre, Hesse, southern Victoria.

discovered in any other regions. At those locations where it was discovered, the frequency of the mutation in the mildew samples was moderate in Tasmania with up to 40% of the population affected. If the population dynamics follow what happened in Europe, it is likely that the WPM population will become more and more resistant to strobilurin fungicides (azoxystrobin (e.g. Radial®, Tazer Xpert®, Amistar Xtra®) and pyraclostrobin (Opera®) relatively quickly (two to three years). In Australia, only two modes of action are registered for WPM control Group 3 (DMI triazoles e.g. epoxiconazole, tebuconazole) and group 11 (QoI strobilurins). However, be aware that strobilurins in broadacre cereal crops are only available in mixtures with triazoles so one might expect that these mixtures will become more dependent on the triazole (Group 3) element in the mixture for the control of the disease if the proportion of mutants in the population increases.

However, with the triazoles, there is a further complication in that in Victoria, NSW and Tasmania, the 'gateway' mutation Y136F has also been discovered in WPM populations. This is a mutation that whilst it is unlikely to affect the field performance of triazole fungicides against WPM, it will enable the population to develop more serious mutations (hence the term gateway). As a result, resistance in the WPM population to triazoles is likely to develop albeit quite slowly in comparison to QoI resistance since it is a multistep resistance based on accumulating multiple mutations (multistep resistance).

So what can growers do to control WPM and minimise further fungicide resistance issues?

- If this disease is prevalent in your region, look to reduce disease pressure by adopting cultivars with good resistance to WPM.
- Use other IDM methods for controlling WPM such as rotating crops where there are infected stubbles, removing the green bridge and using clean seed sources.
- Minimise the use of QoI containing fungicides to one per season, particularly in regions where resistance has not been discovered.
- In regions where QoI resistance has been confirmed, alternate the triazole fungicide used to control powdery mildew since this will assist in preventing the build-up of multi mutations in the pathogen to WPM.
- Please consider sending a sample of active disease to the CCDM since the results inform the research community about the geographic spread of fungicide resistance and the adviser about the appropriate fungicide strategy to adopt.

Acknowledgements

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

We also would like to acknowledge the work of our co-workers and collaborators in these projects. For the STB research FAR00004-a Amanda Pearce and her colleagues in SARDI, Charlie Crozier at Mackillop Farm Management Group, and Jon Midwood and his colleagues at Southern Farming Systems in Victoria and Tasmania. Dr Fran Lopez and his team at the CCDM covering powdery mildew resistance and the collaboration on 'baiting' trial research under Programme 9 of the Grains Research and Development Corporation and Curtin University bilateral.

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Hands Free Hectare (HFHa) – automated agriculture feasibility study

Martin Abell[1], Kit Franklin[2], Jonathan Gill[2] and Clive Blacker[1].

[1]Precision Decisions Ltd; [2]Harper Adams University.

Keywords

- autonomous, auto steer, resolution, legislation, drones.

Take home messages

- A team of three on a budget of £160,000 (GBP) ($275,000 AUD) has demonstrated the full autonomous cultivation of 1ha, equipping conventional farm machinery with open-source drone equipment and accompanying remote agronomy.
- Commercial remote drone agronomy options are a tool to be used to complement conventional techniques and cannot currently replace them.
- Automated agriculture is in the early stages of commercialisation with major original equipment manufacturers (OEMs) and start-ups alike offering solutions to market (on-farm now).
- Autonomous technology is likely to be provided as a service, without growers owning machinery and operations being conducted on a contract basis.
- Legislation remains as the primary barrier to widespread legal adoption of automated machines within all technological sectors including agriculture.

Introduction

The Hands Free Hectare (HFHa) project set out to prove that there was no technological boundary to automated broadacre agriculture. In order to do so the project aimed to prove that a crop could be grown entirely without a foot being set upon the field, both for agricultural and agronomic purposes.

Using modified conventional agricultural machines equipped with the open-source autopilot from a drone to do so, the project demonstrated automated machines as a mechanism to better implement precision farming. Commonly described as the right amount, of the right input, in the right place, at the right time. Automated machines both facilitate the collection of appropriate high-resolution crop data throughout the growing season and the application of targeted inputs at an appropriate resolution, complemented by the collection of high resolution crop performance data. The project also set out to question industry and researchers alike; why hadn't this been done before? It was felt that the technology to farm autonomously in the manner demonstrated had long pre-existed before the project and if not offered commercially should have at least been demonstrated on a research basis previously.

Methodology

A one-year feasibility study was implemented to cultivate a crop of spring barley autonomously, within this year both a conventional trial site and an accompanying autonomous machine trial site were created. The trial sites consisted of a controlled environment, with predetermined dimensions, no obstacles and no machine/human interaction. No headlands were to be farmed, instead they formed 10m grass margins used solely for turning accompanied by 5.0m margins along each side, all within a perimeter fence designed for the automated machines to sense and stop should they drive within a predetermined safe distance.

Automated machines included an; autonomous tractor, combine harvester, crop scout and aerial drones. The autonomous tractor was equipped with a conventional no-till seed drill, crop sprayer and trailer. The crop scout recorded imagery of the crop as it navigated the field, also returning crop samples from the hectare for additional inspection. Finally, a pair of drones were used, the first equipped with a standard red, green and blue (RGB) camera, the second with the ability to capture multispectral imagery, post processed to produce normal difference vegetation index (NDVI) analysis of the crop throughout the growing season.

The one-year time scale was only achievable because of the project's core objective to only use conventional farm machinery and 'off the shelf' technology for automation. Everything used in this project is readily available to purchase. Automation of all machines was implemented using the same methodology; a drone autopilot interfaced with the conventional human controls of each vehicle. Where machines didn't need adaption this was embraced, a mechanically metered seed drill and commercial sprayer rate and section controller were prime examples of this.

Agronomically, the field was flown over as frequently as possible by drone.

Results

The HFHa successfully demonstrated the autonomous cultivation of a spring barley crop. All infield operations were conducted without an operator on the driving seat nor agronomists on the ground.

Successful autonomous farming operations were conducted as shown in Table 1.

Table 1. Autonomous operations upon the Hands Free Hectare project.

Task	Date
Pre-seed blanket herbicide	6 April
Plant and fertiliser	25 April
Roll	28 April
Fungicide 1	5 May
Fertiliser	25 May
Plant growth regulators and micro nutrients	7 June
Selective herbicide	9 June
Fungicide T2	3 July
Pre-harvest herbicide desiccant	15 August
Harvest	6 September

Established the key requirements for commercial adoption; infrastructure and safety systems.

Agronomy questionable; currently a useful tool but still requires human touch for many decisions.

Figure 1. Automated ISEKI TLE3400 Tractor.

Figure 2. Automated Sampo 130 Trials Combine Harvester.

Commercial developments

Original equipment manufacturers (OEMs) and new entrants to the market show how commercially developments are being made with machines available on farm both as products and development prototypes. Although this report focuses on combinable crops, innovation is common place among all agricultural sectors, from fresh produce through to cereals and root crops.

Over the last twenty years tractor manufactures have continued to demonstrate a desire for semi-autonomous capabilities through the development of driver aids. Key examples of these stepping stone technologies include; the introduction of the continuously variable transmission, headland management systems and global positioning system (GPS) guidance. Driver aids such as these all combined form the primary components for an autonomous tractor, with a safety system being the key missing component. Secondly there are a number of current complementary services that manufacturers offer that also form part of a complete autonomous solution; telematics, machine to machine communication and machine to implement communication.

OEMs – Enabling technologies

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Start-Ups

Notes

Small robots?

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Conclusion

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Monitoring mice in Australia

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GRDC project code: AIC00002

Keywords

- mouse monitoring, crop damage, zinc phosphide.

Take home messages

- Mouse numbers are currently moderate across most regions of southern New South Wales (NSW), South Australia (SA) and northwest Victoria (VIC). There is potential for economic damage at sowing in 2018.
- Current efforts to monitor mice are not sufficient to detect variations in mouse abundance between and within cropping regions. Growers need to stay informed about potential increases in mouse numbers from the mouse monitoring updates that the project publishes at the end of each monitoring session. https://www.feralscan.org.au/mousealert/pagecontent.aspx?page=mouse_news
- Growers should conduct their own monitoring to ensure they know what is happening in their own paddocks in the lead up to sowing each autumn. Growers should follow the recommendations outlined in the GRDC GROWNOTES™, Tips and Tactics, Better Mouse Management page at https://grdc.com.au/resources-and-publications/all-publications/publications/2017/07/tips-and-tactics-better-mouse-management
- Broad-scale application of zinc phosphide bait is the only rodenticide available to growers to control mice in their paddocks. Timely application of mouse bait at the prescribed rate is paramount for reducing the impact that mice have on crops at sowing. Strategic use of bait is more effective than frequent use of bait.

Background

'Surveillance and forecasts for mouse outbreaks in Australian cropping systems' is a GRDC investment to monitor and model mouse populations across the grainbelt of Australia. The project started in October 2012 as a collaboration between Landcare Research (New Zealand), CSIRO and the Invasive Animals Cooperative Research Centre.

The aim of the project is to monitor mouse populations across the grain growing regions of Australia and develop predictive models to forecast mouse outbreaks. A key element of the project is to publicise the results of the monitoring and predictions to growers and industry through GRDC and other communication networks to enhance awareness of increases in mouse activity.

Mouse populations are monitored in typical grain farming systems in Western Australia (WA), South Australia (SA), Victoria (VIC), New South Wales (NSW) and Queensland (QLD) at three key times each year, coinciding with important crop stages (e.g. at sowing of winter crops) and critical times in the build-up of mouse populations (e.g. commencement of breeding in spring). The monitoring is used to collect information about the population size, breeding status and overall activity of mice. This information is used in predictive models to determine the probability of changes in mouse abundance. These models were developed at long-term monitoring sites in the northern Adelaide plains in SA, the northwest Mallee in VIC and the Central Darling Downs in southern QLD.

Mouse monitoring

The monitoring of mouse populations occurs at three levels of intensity on 110 transects across 11 sites (Figure 1):

(1) Benchmark sites in the Adelaide Plains (SA), Northwest VIC, and the Darling Downs (QLD), where long-term trapping has been conducted for more than 20 years and where forecast models have been developed. Live trapping data is collected at three key times per year and the data is used in the models to predict the likelihood of outbreaks for those regions.

(2) Quantitative rapid-assessment sites in Geraldton and Ravensthorpe (WA), Horsham and Walpeup (VIC), Riverina, Central West and Moree (NSW), Mallala and Yorke Peninsula (SA) and the Darling Downs and Goondiwindi (QLD) where there are two types of monitoring — mouse chew cards set out overnight (10 chew cards at 10m spacing along 100m survey lines), and active burrow counts along 4m x 100m survey lines. Monitoring is conducted three times a year.

(3) Qualitative monitoring networks in all the areas with rapid-assessment sites where key growers and agronomists are contacted to collect information about mouse activity in the region, as well as any reports of the use of rodenticides.

Issues with monitoring

Current models are performing well and mice are being monitored at a large number of sites across the grain belt, but only a snapshot of what is happening with mouse populations is being gained. There is considerable variability in mouse activity between regions, farms or between paddocks on individual farms that cannot be captured by the monitoring regime. . In an effort to capture this variability, a mobile phone application, MouseAlert (www.mousealert.org.au) was developed with the aim of having growers and agronomists supplement the monitoring program with data about mouse abundance on their farms (Figure 2).

Unfortunately, use of the App has been low and the data collected has been insufficient for use in predictive models. However, the App still provides growers with the opportunity to enter data and view observations of other growers about the level of mouse activity in their district.

Monitoring outcomes

Over the five years that the monitoring project has been running, mouse numbers have fluctuated at all of the monitoring sites — on one occasion in QLD, mouse numbers were significant and damage was recorded on the Darling Downs.

In the spring of 2016, based on the trapping data at Walpeup and Mallala, the models predicted a

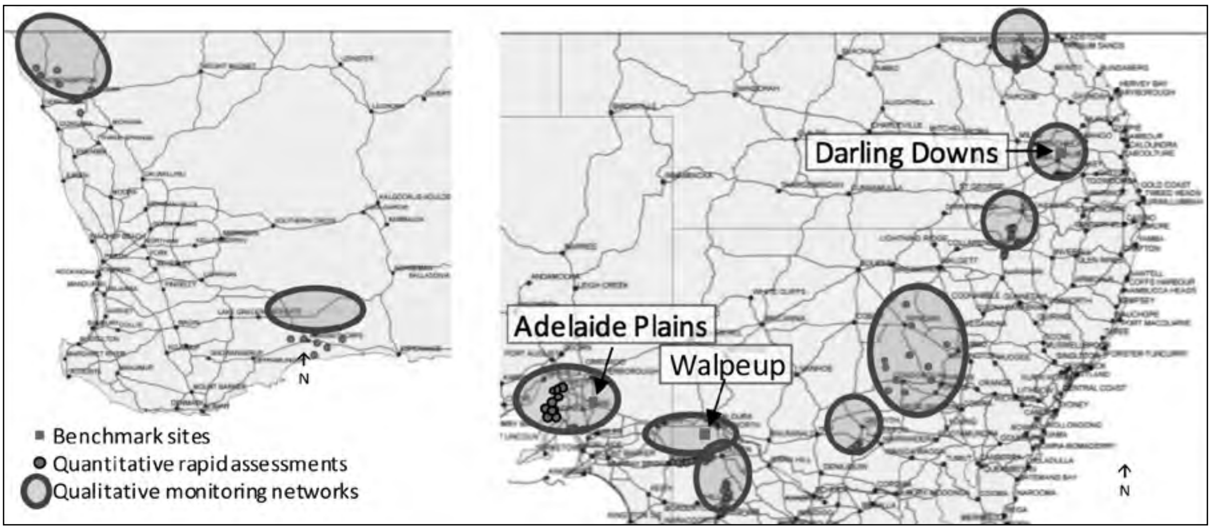

Figure 1. Location of monitoring sites across western, southern and eastern Australia.

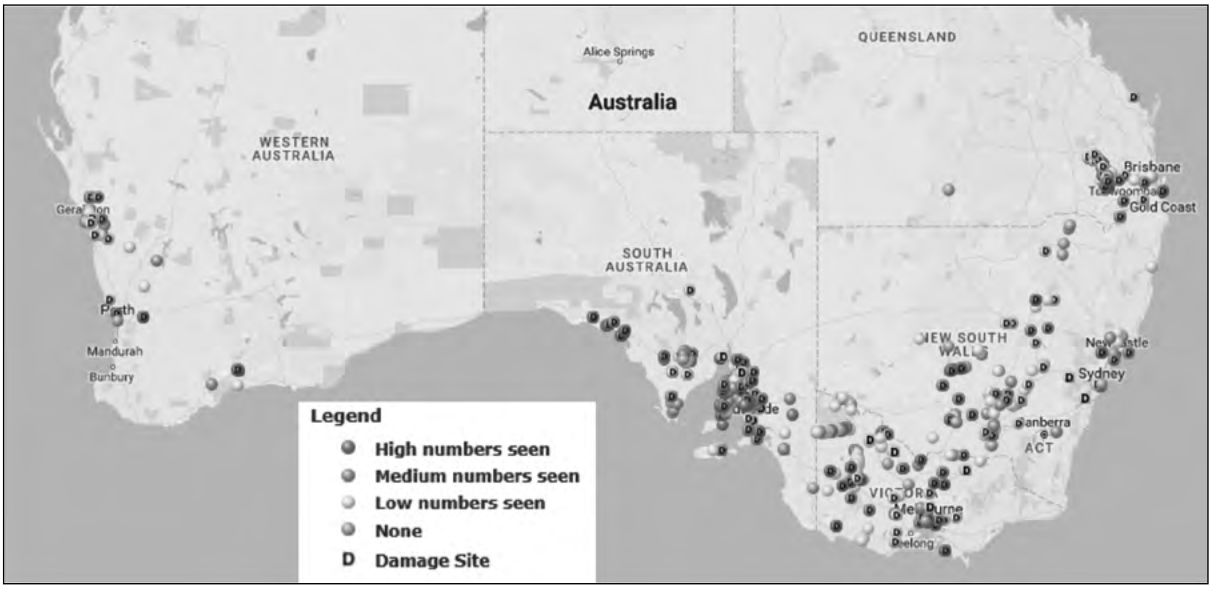

Figure 2. Records of mouse observations in MouseAlert web site/phone app (www.mousealert.org.au) since 2014 (containing > 500 records).

high likelihood of an outbreak in autumn 2017 (Figure 3). Through the summer, numbers of mice in southern NSW, central and western VIC and most cropping regions of SA continued to rise and as a result, growers had to undertake significant baiting programs to reduce damage from mice at sowing in 2017. Despite warnings about the potential for significant increases in mouse numbers, many growers were caught unprepared. This was probably the result of high stubble loads after an exceptional 2016 harvest masked the signs of mouse activity. In some cases where growers anticipated high numbers, baiting was ineffective due to high feed load in the system.

Mice continued to be a problem throughout the 2017 crop. Monitoring early in the spring showed little or no sign of activity associated with active burrow counts or crop damage, but a significant level of activity was recorded on the chew cards. Adjusted trap success in north western VIC was significantly higher than expected for the spring trapping, indicating that breeding had started early.

Later in the spring, significant amounts of damage were recorded in many of the developing crops. Anecdotal reports of damage to all types of crops continued to be reported right up to harvest and reports of higher than expected numbers of mice through the harvest were not uncommon. Severe

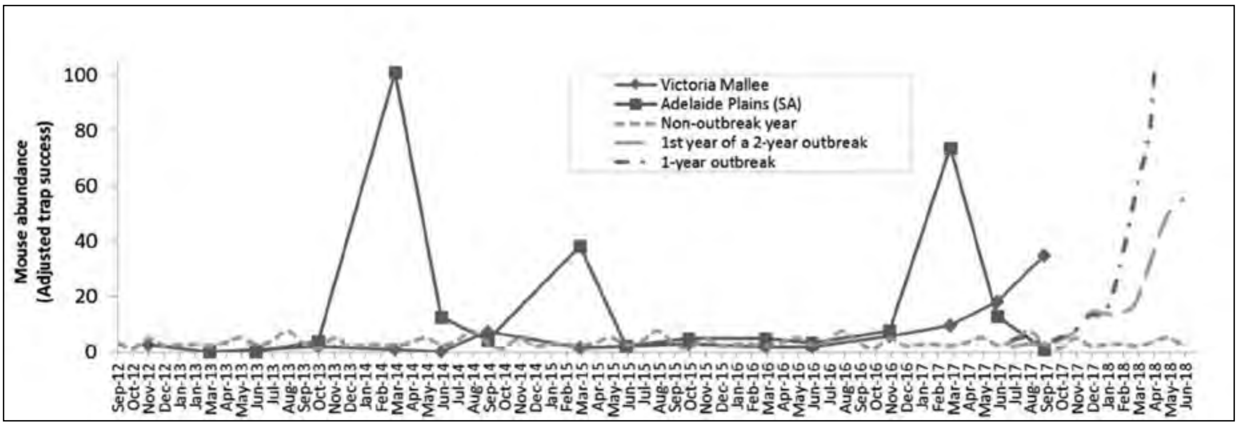

Figure 3. Current mouse population abundance at benchmark sites in VIC and SA compared to outbreaks in the past.

weather events during the 2017 crop resulted in significant crop losses in some areas due to dropped grain or frost damage, resulting in a greater than normal supply of food for mice.

Mouse control issues

More data is needed to make accurate predictions about changes in mouse abundance across cropping regions. Monitoring and data collection currently is labour intensive and inefficient and would benefit from developing a remote monitoring system that could detect changes in mouse activity on a broad scale.

The current approach to bait application is to spread bait on a broad scale across entire paddocks. Our understanding of mouse ecology and behaviour is based on work undertaken in conventional cropping systems. Understanding mouse ecology in zero and no-till cropping systems could lead to more strategic application of bait, potentially reducing the quantity of bait spread or increasing the effectiveness of bait by targeting high activity zones in paddocks.

Future development of new rodenticides for mouse control is still some time away and the development of novel biocontrol techniques has potential, but is still in the very early stages of development. In the interim, there is a need to find ways to use the tools that are available to control mice more effectively.

Acknowledgements

The research undertaken as part of this project, IAC00002, is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC. The authors would like to thank them for their continued support.

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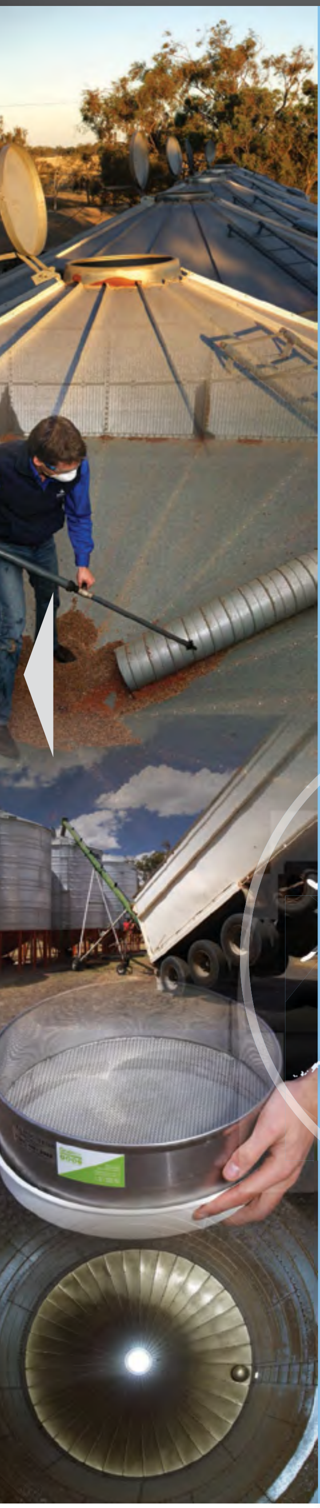

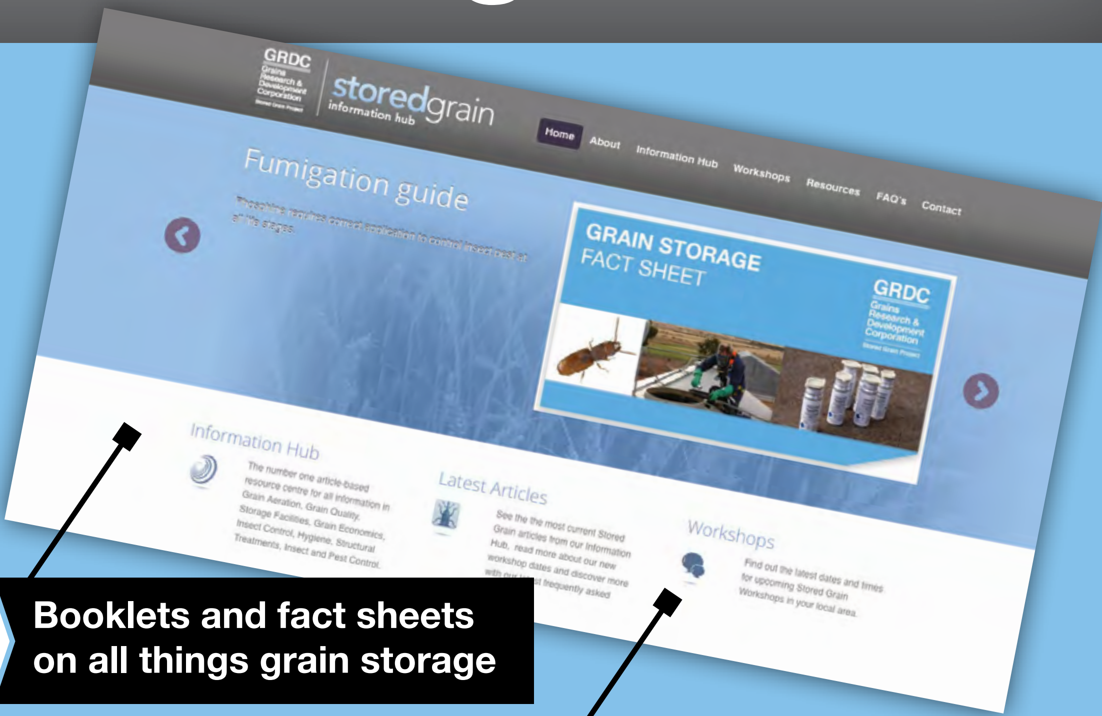

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Herbicide and weed management - latest research

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GRDC project codes: UA00149, UA00156, USC00020

Keywords

- herbicide resistance, prosulfocarb, triallate, sowthistle, Indian hedge mustard, windmill grass, feathertop Rhodes grass.

Take home messages

- Annual ryegrass with resistance to the Group D and Group J pre-emergent herbicides will make management in cereals difficult.
- Indian hedge mustard populations have resistance to Groups B, C, F and I herbicides, greatly reducing control options in break crops.
- Common sowthistle with resistance to imidazolinone (IMI) herbicides is difficult to control in lentil crops, so control has to occur in cereals.
- Windmill grass and feathertop Rhodes grass are two emerging summer weeds with glyphosate resistance. Better understanding of their emergence and growth patterns will aid control.

Resistance to pre-emergent herbicides in annual ryegrass

With resistance to post-emergent herbicides in grass weeds, particularly in annual ryegrass, there has been increased reliance on pre-emergent herbicides for weed control. Pre-emergent herbicides are now one of the most important components of annual ryegrass management. Resistance to trifluralin has been present in South Australia (SA) for many years and by 2005, resistance to trifluralin was widespread. This resulted in early adoption of Boxer Gold® when it was released in 2008 and of Sakura® in 2012. The heavy dependence on Group J herbicides in recent years has led to resistance to this mode of action. Resistance to Group J herbicides in annual ryegrass has occurred in SA, VIC and NSW. In all cases, the populations also have resistance to trifluralin, suggesting that once trifluralin has failed, selection pressure shifts to other pre-emergent herbicides. Due to the existing widespread resistance to trifluralin in annual ryegrass in SA, resistance to the Group J herbicides will leave one mode of action available for control of annual ryegrass in cereals.

The situation may be even worse than this. In one population of annual ryegrass from the Eyre Peninsula with resistance to Group J herbicides that has been well characterised, resistance occurs across many herbicides of this mode of action (Table 1). As expected, this population also has resistance to trifluralin. More concerning, there is a reduction in susceptibility to both propyzamide and pyroxasulfone (Sakura®). The current ability to manage annual ryegrass with pre-emergent herbicides could be threatened if more populations like this appear.

Table 1. Concentration of various pre-emergent herbicides required for 50% mortality (LD_{50}) of example resistant and susceptible annual ryegrass populations with resistance index (RI).				
Herbicide (with Group)	Annual ryegrass population			RI*
	SLR4 (S)	VLR1 (S)	EP162 (R)	
	LD_{50} (g a.i. ha^{-1})			
Triallate (J)	248	181	3188	14.9
Prosulfocarb (J)	311	246	2608	9.4
EPTC (J)	305	288	2867	9.7
Trifluralin (D)	39	27	455	13.8
Propyzamide (D)	30	23	74	2.7
Pyroxasulfone (K)	9.5	6.2	64	8.1

**RI = LD_{50} of R population divided by LD50 of S populations.*

Table 2. Extent of herbicide resistance in Indian hedge mustard populations from SA and VIC. Samples collected randomly at harvest from single fields. Resistant samples had greater than 20% survival at the normal field rate in testing.			
Herbicide (with Group)	Year and region		
	2013 Mid-North SA	2014 Eyre Peninsula SA	2015 Wimmera/Mallee VIC
	Samples with resistance (%)		
Chlorsulfuron (B)	25	64	37
Imazamox + Imazapyr (B)	13	14	5
Atrazine (C)	0	7	32
Diflufenican (F)	0	36	37
2,4-D (I)	0	7	16
Glyphosate (M)	0	0	0

**RI = LD_{50} of R population divided by LD50 of S populations.*

Multiple resistance in Indian hedge mustard

Indian hedge mustard has been a problematic broadleaf weed in SA for some years. It evolved resistance to the Group B herbicides early and in recent years, populations with resistance to 2,4-D, atrazine and diflufenican have been identified. Resistance to all of these herbicides is turning up in the random weed surveys being conducted across SA and VIC (Table 2). The frequency of samples with resistance to the Group C and Group F herbicides appears to be increasing rapidly.

Multiple resistance across all of Groups B, C, F and I was also present (Table 3). Of the 50 populations collected in random surveys since 2013, only 38% were susceptible to all herbicides, 36% had resistance to one mode of action, 18% had resistance to two modes of action, 6% had resistance to three different modes of action and one population had resistance to all four modes of action.

Table 3. Action plan for objective/goal 1.	
Herbicide Groups with resistance	Samples (% of total)
Susceptible to all	38
B	22
C	2
F	10
I	2
B + C	2
B + F	10
C + F	6
B + C + F	4
B + F + I	2
B + C + F + I	2

Clearly, this multiple resistance will make managing Indian hedge mustard more difficult. There remain some herbicide options that are still effective, in particular herbicide mixtures with bromoxynil seem to be providing effective control in cereals, however, options for pulse crops are limited.

Crop topping can be used to reduce seed set in canola and pulse crops. Good control will have to be achieved in the cereal phase to reduce the weed seed bank heading into break crops.

Herbicide resistance in common sowthistle

Common sowthistle is another broadleaf weed species that has been increasing in importance recently due to herbicide resistance. Common sowthistle, Indian hedge mustard and prickly lettuce, evolved resistance to the Group B herbicides in SA early. Initially, Group B resistance in common sowthisle was restricted to the sulfonylurea (SU) herbicides. More recently, populations with resistance to IMI herbicides have appeared. Our most recent random resistance survey found nearly as much resistance to IMI herbicides (63% of populations) as to SU herbicides (72% of populations). The selection of IMI resistance has been the result of increased use of Clearfield® crops and associated IMI herbicides, particularly with lentils in SA.

Common sowthistle has also evolved resistance to Group I herbicides in SA. Resistance has occurred across the Group I herbicides, such as 2,4-D and clopyralid (Lontrel®). Resistance to glyphosate in this species has also appeared in NSW and QLD. Resistance to Group I herbicides in common sowthistle reduces the number of options for control both in crop and during summer fallow. With resistance to Group B, Group I and glyphosate, all of the inexpensive summer control options are gone.

The increasing prevalence of herbicide resistance in common sowthistle is a major reason why it is becoming difficult to manage in lentil production. The good news is that sowthistle has a short-lived weed seed bank of little more than 12 months. This means that effective control in cereal crops should be able to reduce problems in subsequent lentil crops. As there are few remaining effective control methods for sowthistle in lentils, growing lentil crops close together in the rotation will exacerbate sowthistle problems.

While common sowthistle seed is blown by wind and a small amount can move a long way, most of the seed falls within 100m of the parent plant. Spring germinating common sowthistle struggles to establish in competitive cereal crops and growing more competitive cereals will reduce the amount of sowthistle plants that can persist through harvest. Ensuring surviving plants do not set seed in crop fields, as well as pastures and fence lines, will have a large impact in reducing populations for the next cropping season. Common sowthistle is still susceptible to some herbicides and herbicide mixtures from Groups C, G, H and L. These are typically more expensive options, but using them in some paddocks to take the pressure off other modes of action will help.

Glyphosate resistance in feathertop Rhodes grass and windmill grass

Feathertop Rhodes grass and windmill grass are two summer-growing grass species that are starting to be more problematic in grain cropping in southern Australia. These are spring germinating species that have natural tolerance to glyphosate, although glyphosate can control both species if applied to small seedlings at robust rates. Both of these species are present in SA, but mainly on roadsides. Despite having tolerance to glyphosate, both species have also evolved resistance to glyphosate. Roadside populations of both species with glyphosate resistance have been identified and these move easily into cropped fields.

Feathertop Rhodes grass is an annual grass species that germinates mainly in spring and early summer in SA. Seasons with higher spring rainfall, such as 2016, will have larger flushes of germination. Feathertop Rhodes grass grows rapidly after germination and can set seed within two months in summer. Each plant can produce up to 40,000 seeds and seeds can move up to 30m by wind. Transport of seeds is aided by vehicles and farm equipment. The soil seed bank persists for about 12 months (Figure 1), but lasts longer following wetter summers. Persistence is greater for seed on the surface than for buried seed.

The ideal time to control feathertop Rhodes grass is when seedlings are small. Unfortunately, the common pre-emergent herbicides used in SA grain production are not effective at reducing feathertop Rhodes grass germination in spring. This means that control needs to occur as soon after harvest as possible and before weeds set seed.

Windmill grass is a slower growing plant than feathertop Rhodes grass taking longer to reach maturity. However, windmill grass is a short-lived perennial species and while seedlings can be controlled relatively easily, mature plants are very difficult to kill with herbicides. Like feathertop Rhodes grass, windmill grass typically germinates in spring in SA. The soil seed bank life of windmill grass is longer than feathertop Rhodes grass (Figure 1).

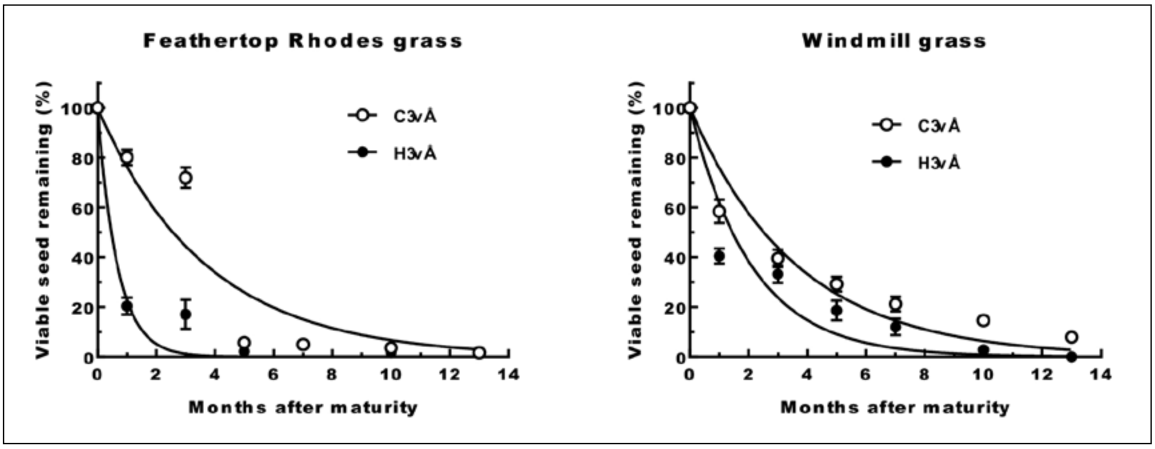

Figure 1. Persistence of seed of feathertop Rhodes grass (left) and windmill grass (right) on the soil surface (O) or buried at 5cm (●). From Ngo et al. (2017a; 2017b).

Windmill grass seed is less mobile than feathertop Rhodes grass and so new infestations are likely to be seen close to roadside fences. Controlling these infestations early before they fully establish is essential to reduce the costs of later control.

Useful resources

https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

https://agwine.adelaide.edu.au/research/farming-systems/weed-science/factsheets/2017_WMG_Biology.pdf

https://agwine.adelaide.edu.au/research/farming-systems/weed-science/factsheets/2017_FTR_Biology.pdf

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Notes

THE 2017-2019 GRDC SOUTHERN REGIONAL PANEL

FEBRUARY 2018

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHAIR - KEITH PENGILLEY

Based at Evandale in the northern Midlands of Tasmania, Keith was previously the general manager of a dryland and irrigated family farming operation at Conara (Tasmania), operating a 7000 hectare mixed-farming operation over three properties. He is a director of Tasmanian Agricultural Producers, a grain accumulation, storage, marketing and export business. Keith is the chair of the GRDC Southern Regional Panel which identifies grower priorities and advises on the GRDC's research, development and extension investments in the southern grains region.

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DEPUTY CHAIR - MIKE MCLAUGHLIN

Mike is a researcher with the University of Adelaide, based at the Waite campus in South Australia. He specialises in soil fertility and crop nutrition, contaminants in fertilisers, wastes, soils and crops. Mike manages the Fertiliser Technology Research Centre at the University of Adelaide and has a wide network of contacts and collaborators nationally and internationally in the fertiliser industry and in soil fertility research.

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JOHN BENNETT

Based at Lawloit, between Nhill and Kaniva in Victoria's West Wimmera, John, his wife Allison and family run a mixed farming operation across diverse soil types. The farming system is 70 to 80 percent cropping, with cereals, oilseeds, legumes and hay grown. John believes in the science-based research, new technologies and opportunities that the GRDC delivers to graingrowers. He wants to see RD&E investments promote resilient and sustainable farming systems that deliver more profit to growers and ultimately make agriculture an exciting career path for young people.

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PETER KUHLMANN

Peter is a farmer at Mudamuckla near Ceduna on South Australia's Western Eyre Peninsula. He uses liquid fertiliser, no-till and variable rate technology to assist in the challenge of dealing with low rainfall and subsoil constraints. Peter has been a board member of and chaired the Eyre Peninsula Agricultural Research Foundation and the South Australian Grain Industry Trust.

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FIONA MARSHALL

Fiona has been farming with her husband Craig for 21 years at Mulwala in the Southern Riverina. They are broadacre, dryland grain producers and also operate a sheep enterprise. Fiona has a background in applied science and education and is currently serving as a committee member of Riverine Plains Inc, an independent farming systems group. She is passionate about improving the profile and profitability of Australian grain growers.

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JON MIDWOOD

Jon has worked in agriculture for the past three decades, both in the UK and in Australia. In 2004 he moved to Geelong, Victoria, and managed Grainsearch, a grower-funded company evaluating European wheat and barley varieties for the high rainfall zone. In 2007, his consultancy managed the commercial contract trials for Southern Farming Systems (SFS). In 2010 he became Chief Executive of SFS, which has five branches covering southern Victoria and Tasmania. In 2012, Jon became a member of the GRDC's HRZ Regional Cropping Solutions Network.

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ROHAN MOTT

A fourth generation grain grower at Turriff in the Victorian Mallee, Rohan has been farming for more than 25 years and is a director of Mott Ag. With significant on-farm storage investment, Mott Ag produces wheat, barley, lupins, field peas, lentils and vetch, including vetch hay. Rohan continually strives to improve productivity and profitability within Mott Ag through broadening his understanding and knowledge of agriculture. Rohan is passionate about agricultural sustainability, has a keen interest in new technology and is always seeking ways to improve on-farm practice.

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RICHARD MURDOCH

Richard along with wife Lee-Anne, son Will and staff, grow wheat, canola, lentils and faba beans on some challenging soil types at Warooka on South Australia's Yorke Peninsula. They also operate a self-replacing Murray Grey cattle herd and Merino sheep flock. Sharing knowledge and strategies with the next generation is important to Richard whose passion for agriculture has extended beyond the farm to include involvement in the Agricultural Bureau of SA, Advisory Board of Agriculture SA, Agribusiness Council of Australia SA, the YP Alkaline Soils Group and grain marketing groups.

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RANDALL WILKSCH

Based at Yeelanna on South Australia's Lower Eyre Peninsula, Randall is a partner in Wilksch Agriculture, a family-owned business growing cereals, pulses, oilseeds and coarse grain for international and domestic markets. Managing highly variable soil types within different rainfall zones, the business has transitioned through direct drill to no-till, and incorporated CTF and VRT. A Nuffield Scholar and founding member of the Lower Eyre Agricultural Development Association (LEADA), Randall's off-farm roles have included working with Kondinin Group's overview committee, the Society of Precision Agriculture in Australia (SPAA) and the Landmark Advisory Council.

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KATE WILSON

Kate is a partner in a large grain producing operation in Victoria's Southern Mallee region. Kate and husband Grant are fourth generation farmers producing wheat, canola, lentils, lupins and field peas. Kate has been an agronomic consultant for more than 20 years, servicing clients throughout the Mallee and northern Wimmera. Having witnessed and implemented much change in farming practices over the past two decades, Kate is passionate about RD&E to bring about positive practice change to growers.

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BRONDWEN MACLEAN

Brondwen MacLean has spent the past 20 years working with the GRDC across a variety of roles and is currently serving as General Manager for the Applied R&D business group. She has primary accountability for managing all aspects of the GRDC's applied RD&E investments and aims to ensure that these investments generate the best possible return for Australian grain growers. Ms MacLean appreciates the issues growers face in their paddocks and businesses. She is committed to finding effective and practical solutions `from the ground-up'.

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2017–2019 SOUTHERN REGIONAL CROPPING SOLUTIONS NETWORK (RCSN)

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The RCSN initiative was established to identify priority grains industry issues and desired outcomes and assist the GRDC in the development, delivery and review of targeted RD&E activities, creating enduring profitability for Australian grain growers. The composition and leadership of the RCSNs ensures constraints and opportunities are promptly identified, captured and effectively addressed. The initiative provides a transparent process that will guide the development of targeted investments aimed at delivering the knowledge, tools or technology required by growers now and in the future. Membership of the RCSN network comprises growers, researchers, advisers and agribusiness professionals. The three networks are focused on farming systems within a particular zone – low rainfall, medium rainfall and high rainfall – and comprise 38 RCSN members in total across these zones.

REGIONAL CROPPING SOLUTIONS NETWORK SUPPORT TEAM

SOUTHERN RCSN CO-ORDINATOR: JEN LILLECRAPP

Jen is an experienced extension consultant and partner in a diversified farm business, which includes sheep, cattle, cropping and viticultural enterprises. Based at Struan in South Australia, Jen has a comprehensive knowledge of farming systems and issues affecting the profitability of grains production, especially in the high rainfall zone. In her previous roles as a district agronomist and operations manager, she provided extension services and delivered a range of training programs for local growers. Jen was instrumental in establishing and building the MacKillop Farm Management Group and through validation trials and demonstrations extended the findings to support growers and advisers in adopting best management practices. She has provided facilitation and coordination services for the high and medium rainfall zone RCSNs since the initiative's inception.

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LOW RAINFALL ZONE CO-LEAD: BARRY MUDGE

Barry has been involved in the agricultural sector for more than 30 years. For 12 years he was a rural officer/regional manager in the Commonwealth Development Bank. He then managed a family farming property in the Upper North of SA for 15 years before becoming a consultant with Rural Solutions SA in 2007. He is now a private consultant and continues to run his family property at Port Germein. Barry has expert and applied knowledge and experience in agricultural economics. He believes variability in agriculture provides opportunities as well as challenges and should be harnessed as a driver of profitability within farming systems. Barry was a previous member of the Low Rainfall RCSN and is current chair of the Upper North Farming Systems group.

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LOW RAINFALL ZONE CO-LEAD: JOHN STUCHBERY

John is a highly experienced, business-minded consultant with a track record of converting evidence-based research into practical, profitable solutions for grain growers. Based at Donald in Victoria, John is well regarded as an applied researcher, project reviewer, strategic thinker and experienced facilitator. He is the founder and former owner of JSA Independent (formerly John Stuchbery and Associates) and is a member of the SA and Victorian Independent Consultants group, a former FM500 facilitator, a GRDC Weeds Investment Review Committee member, and technical consultant to BCG-GRDC funded 'Flexible Farming Systems and Water Use Efficiency' projects. He is currently a senior consultant with AGRIvision Consultants.

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HIGH RAINFALL ZONE LEAD: CAM NICHOLSON

Cam is an agricultural consultant and livestock producer on Victoria's Bellarine Peninsula. A consultant for more than 30 years, he has managed several research, development and extension programs for organisations including the GRDC (leading the Grain and Graze Programs), Meat and Livestock Australia and Dairy Australia. Cam specialises in whole-farm analysis and risk management. He is passionate about up-skilling growers and advisers to develop strategies and make better-informed decisions to manage risk – critical to the success of a farm business. Cam is the program manager of the Woady Yaloak Catchment Group and was highly commended in the 2015 Bob Hawke Landcare Awards.

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MEDIUM RAINFALL ZONE LEAD: KATE BURKE

An experienced trainer and facilitator, Kate is highly regarded across the southern region as a consultant, research project manager, public speaker and facilitator. Based at Echuca in Victoria, she is a skilled strategist with natural empathy for rural communities. Having held various roles from research to commercial management during 25 years in the grains sector, Kate is now the managing director of Think Agri Pty Ltd, which combines her expertise in corporate agriculture and family farming. Previously Kate spent 12 years as a cropping consultant with JSA Independent in the Victorian Mallee and Wimmera and three years as a commercial manager at Warakirri Cropping Trust.

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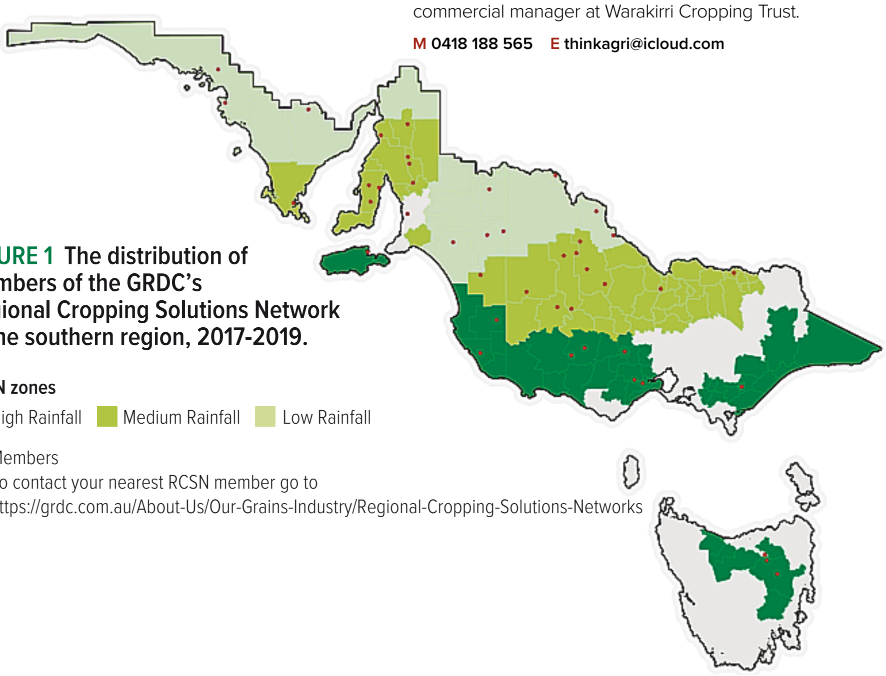

FIGURE 1 The distribution of members of the GRDC's Regional Cropping Solutions Network in the southern region, 2017-2019.

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- The local GRDC Grains Research Update steering committee that includes both government and private consultants and GRDC employees.
- Partnering organisation: YP Alkaline Soils Group

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2018 Bute GRDC Grains Research Update Evaluation

1. Name

ORM has permisssion to follow me up in regards to post event outcomes.

2. How would you describe your main role? *(choose one only)*

- ❑ Grower
- ❑ Agronomic adviser
- ❑ Farm business adviser
- ❑ Financial adviser
- ❑ Communications/extension
- ❑ Grain marketing
- ❑ Farm input/service provider
- ❑ Banking
- ❑ Accountant
- ❑ Researcher
- ❑ Student
- ❑ Other* (please specify)

Your feedback on the presentations

For each presentation you attended, please rate the content relevance and presentation quality on a scale of 0 to 10 by placing a number in the box (**10 = totally satisfactory, 0 = totally unsatisfactory**).

3. Harvest weed seed control – advisers and growers spoilt for choice: *Peter Newman*

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

4. Septoria tritici update and latest developments in powdery mildew management: *Nick Poole*

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

5. Hands Free Hectare (HFHa) – automated agriculture feasibility study: *Martin Abell*

Content relevance /10 Presentation quality /10

Have you got any comments on the content or quality of the presentation?

6. Monitoring mice in Australia: *Steve Henry*

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

7. Herbicide and weed management - latest research: *Chris Preston*

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

Your next steps

8. Please describe at least one new strategy you will undertake as a result of attending this Update event

9. What are the first steps you will take?

e.g. seek further information from a presenter, consider a new resource, talk to my network, start a trial in my business

Your feedback on the Update

10. Thinking about your Update experience, please consider how strongly you agree or disagree with the following statements

	Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly disagree
This Update has increased my awareness and knowledge of the latest in grains research	❑	❑	❑	❑	❑
Participating in this event has reinforced or enhanced my industry networks	❑	❑	❑	❑	❑
I know who to talk to, or where to go, to further explore the information that interested me	❑	❑	❑	❑	❑

Comments

11. Are there any subjects you would like covered in the next Update?

12. What is the likelihood you will attend an Update event like this in the future?

Very likely	Likely	May or may not	Unlikely	Will not attend
❑	❑	❑	❑	❑

Comments

13. Overall, how did the Update event meet your expectations?

Very much exceeded	Exceeded	Met	Partially met	Did not meet
❑	❑	❑	❑	❑

Comments

14. Finally, do you have any comments or suggestions to improve the GRDC Update events?

Thank you for your feedback.

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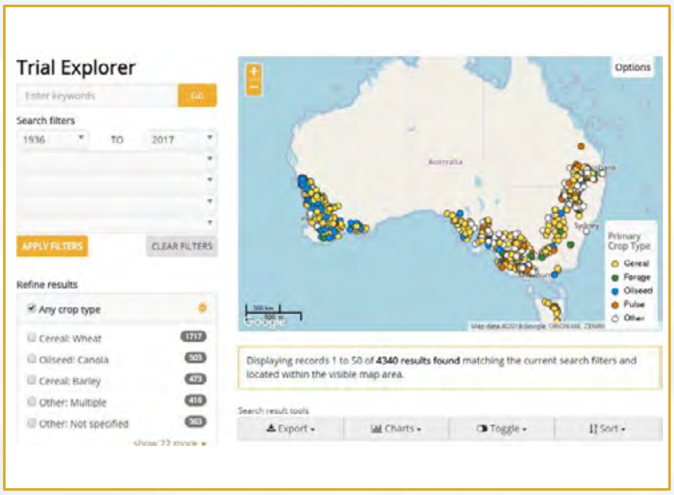

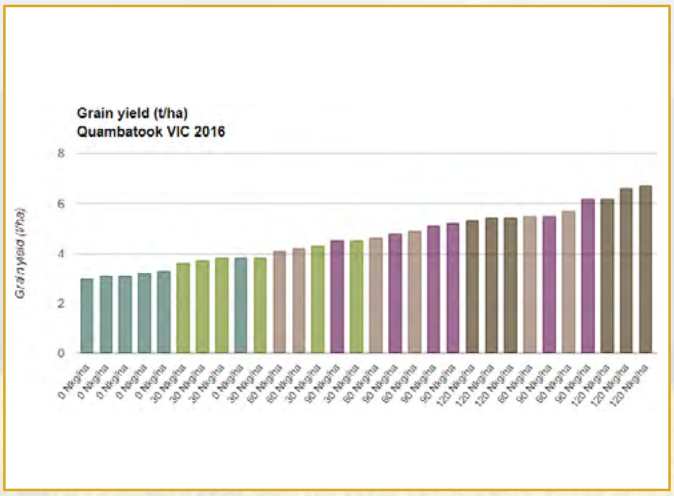

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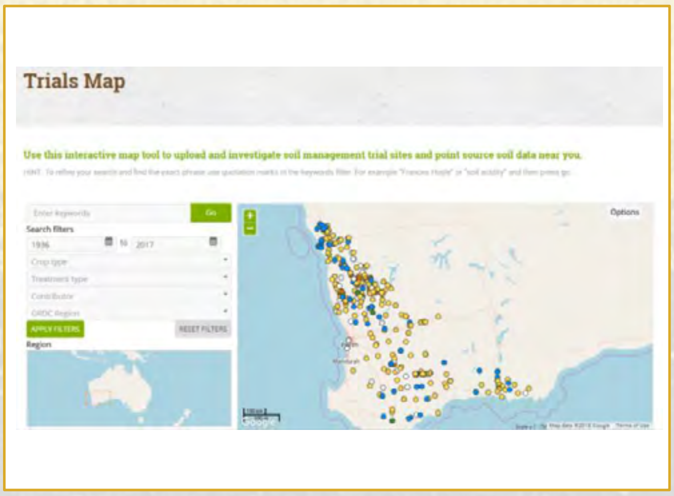

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