GRDC investments addressing “deep dive” issues – Low Rainfall Zone Southern RCSN – January 2019

Issue No. 29 - Seed banks of problem grass weeds are increasing because harvest weed seed management is not being fully utilised

GRDC investments addressing this issue

Assessment of some harvest weed seed management options for Kwinana West, Kwinana East and Esperance port zone growers (PLN00013-B)	Aims: This project addressed three main HWSC issues: 1. Setting up a harvester for chaff lining or chaff tramlining. This involved ten case studies of Esperance grain growers who have been using this practice with great success giving clear guidelines of the benefits and how to choose between the two. It is estimated that over one third of Australian grain growers will be using one of these HWSC tools within three years. 2. Capturing weed seeds into the front of the harvester in low biomass crops. 3. Harvester set up for harvest weed seed control. Results: Ten case studies were reported as well as a literature review on the topic. Low rainfall regions typically grow low biomass crops with wide row spacing and low seeding rates leading to high levels of weed seeds being present below the harvest height. This project identified that growers are making the best of what they have by harvesting low, harvesting weedy paddocks first as well as harvester front modifications, however we feel that there is room for an engineering solution to increase the capture of weed seeds in low biomass crops. The workshops run as part of this project were extremely well attended and highly rated by the growers. It shows that growers have had enough about talking about adopting HWSC, they are now doing it and they are now ready to talk about HOW to do it. There is a lot to learn about the separation of weed seeds into the chaff fraction within the harvester.
Chafflining in the Geraldton port zone - a new, cost effective harvest weed seed control tool (PLN1802-002SAX)	Aims: This project will summarise what is currently known about the new practice, chafflining, as well as harvest weed seed control in low biomass crops. We will also deliver four practical grower workshops in the Geraldton port zone about setting up a range of models of harvester for harvest weed seed control. Results: A draft Tools and Tips – chafflining has been produced. This document will help growers who are setting up their machines for chafflining. Four workshops covering harvester set up for harvest weed seed control were delivered in the Geraldton port zone in the weeks leading up to harvest 2018.

Harvest weed seed control for the southern region (SFS00032)	<u>Aims:</u> The high rainfall zones (HRZ) of the GRDC southern region have specific attributes that vary significantly from MRZ and LRZ. The HRZ has consistently high yield potentials that impact on crop, stubble and weed architecture. Currently 70-80% of SE Victorian growers burn stubble residues to provide trouble free establishment of the next season's crop, reduce disease carry over and control pests such as slugs, snails and mice. To maximize yield potential crops need to be sown on narrow row spacing's, <225mm, and maximizing yield (up to 10t/ha in SE Victoria, SFS trials results 2013) produces very high stubble loads. The proposed project will investigate the efficacy of a range of HWSC practices at 7 sites across the GRDC southern region HRZ zone. <u>Results:</u> The efficacy of HWSC in the Southern HRZ is challenged both by the large number of weed seeds produced by populations that are consistently greater than 100 plants/m2 in winter, and by long growing seasons that give ARG time to shed 40 to 80% of its seeds. Cutting at 30cm instead of 15cm will reduce the costs associated with HWSC in other regions and may not further compromise its efficacy. Cutting hay could prevent seed shedding and drastically improve the management of ARG in the southern HRZ. Whether this overcomes the problem posed by initially high weed numbers is uncertain.
Emerging weeds (UA00156)	<u>Aims:</u> Information on seed biology and persistence of weed seedbanks of many of the emerging weeds in Australia is largely unknown. Furthermore, much of the Australian research on weed seed biology was undertaken prior to the intensification of cropping and before the introduction of no-till systems. It is quite likely that the behaviour of many weeds may have changed considerably in response to the changes in crop management practices. Increasing our knowledge of seed dormancy, seedling emergence patterns and seedbank persistence of emerging weed species will assist growers in making more informed decisions on weed management. <u>Results:</u> Research undertaken in 2016 has confirmed presence of large variation in seed dormancy between weed populations in some weed species such as barley grass and brome grass from the southern region. Barley grass and brome populations from cropping fields had greater seed dormancy and were much slower to emerge than populations from non-crop areas. Many other weed species displayed a much smaller variation in seed dormancy. There were large differences between weed species in the pattern of recruitment and the level of exhaustion of the seedbank. However, site rainfall during the study did not have a significant effect on the persistence of seedbank of most of the weed species. Generally weed seeds present on the soil surface had a greater rate of decay than buried seeds. Weed species with rapid germination and greater early vigour were more competitive with crops and produced more seeds. There were also major differences between weed species in the rate of seed shedding/dispersal until harvest time. Seed retention until crop harvest also varied between weed species. At the time when wheat was ready for harvest, less than 5% of barley grass seeds were retained on the plant (i.e. 95% shed). In contrast, retention was higher for bifora (20%) and brome grass (26%), but the level of seed retention in 2017 was much lower than in the previous year (2016: bifora 50% and brome 75%). These results clearly highlight the influence of seasonal conditions on the seed shedding behaviour of these weeds. Lower level of competition for water in lentils appeared to delay the maturity and reduce the level of seed shed in weed species. However, bedstraw, turnip weed, Indian hedge mustard and statice showed no seed dispersal prior to the harvest-ready stage of both crops (100% retained). These findings have important implications for the effectiveness of harvest weed seed control for different weed species. Work in 2019 will provide evidence of the rapid decay of weed seeds during summer-autumn period in chaff lining Harvest Weed Seed Control systems in southern and western regions.
US00084 Innovative crop weed control for northern region cropping systems	<u>Aims:</u> Work has aimed to investigate the survival of wild oat, annual ryegrass, turnip weed, and common sowthistle seeds placed under wheat and barley chaff on tramlines. Pot studies are also examining the effects of chaff type and amount on the emergence of annual ryegrass and common sowthistle. <u>Results:</u> The amount of chaff deposited in chaff tramlines is likely to influence the fate of weed seeds, and this is in turn dependent on crop type, planting density, row spacing, header set-up, harvest speed, and the type of header front used (with less chaff produced by a stripper front). The efficacy of HWSC techniques, including chaff lining and chaff tramlining, will depend on maximum capture of weed seeds at harvest time.

	By using chaff tramlining or chaff lining, weed seeds captured during harvest are concentrated into one or two lines per header pass, where they can be monitored and treated in targeted weed control strategies (e.g. using high rates and a shielded sprayer).
Low weed seed bank persistence under sustained integrated weed management (UWA1711-005RTX)	Aims: In Australia, with the widespread evolution of multiple herbicide resistance in wild radish (Raphanus raphanistrum L.) populations, harvest weed seed control (HWSC) has been relied upon to intercept and destroy weed seeds at harvest before they replenish the soil seed bank. As a result of effective herbicide treatments and HWSC, herbicide resistant wild radish soil seed banks have been put into steep decline demonstrating that even in the midst of multiple herbicide resistance, low weed seed banks are possible. Evolutionary theory however suggests that the effectiveness of HWSC is expected to directly select for traits that enable wild radish to evade control. Results: In this study it was found that wild radish populations exposed to long term HWSC were found to require less time from emergence to flowering compared to the three regionally locally collected control populations. When grown in common conditions, the mean flowering time of the HWSC selected populations were at least 10 days earlier than the non-HWSC control populations. Whilst HWSC selected populations had a shorter reproductive period, it was also found that these populations did not produce less seed than non HWSC control populations, indicating any potential pod shedding adaptation has a limited reproductive cost. Whist all populations produced a significant amount of seed, the mean rate of fruit abscission in HWSC selected populations was greater. Wild radish is known for its significant genetic variability and this was demonstrated by the significant variability in fruit abiscission rates within each wild radish population tested. The mean height of the lowest pod was also found to be lower amongst HWSC selected populations with a correlation between the time from emergence to flowering and the height of the lowest pod demonstrated. The results of the 2017 phenotyping study indicate that the putative pod shedding HWSC selected populations have an adapted phenotype favouring a shorter "bush" type form that matures earlier and, shedding more pods before harvest.
Stubble Initiative – Component No. 1 – Research – CSIRO – various milestones	Milestone 14 – A review summarising existing data for efficacy of practices to control ryegrass, brome and barley grass weeds in situations relevant to the stubble initiative practices and regions. This will include consultation with relevant groups focussed on weeds, and description of new data collection from relevant regional group experiments to fill data gaps Milestone 15 - Development of an adapted tool (based on RIM) for analysis of integrated weed management options for ryegrass and workshops conducted using the tool with at least 3 regional groups. Milestone 16 - Development of new tools (based on RIM) for analysis of integrated weed management options for brome and barley grass incorporating new data and understanding of weed population dynamics, tools used in workshops with 3 regional groups. Milestone 17 - Release of the 2 new downloadable tools (based on RIM) for brome and barley grass integrated weed management evaluation and a report characterising the sustainability of a range of stubble-retained cropping systems/practices in terms of weed population management and resistance risk. This will include evaluation of practices that would add or threaten sustainability.
WeedSmart (UWA001724)	Aims: WeedSmart is established by industry to ensure herbicide options are available for future generations. WeedSmart provides a consistent, single voice for the herbicide industry, linking stakeholders to world renowned herbicide resistance and agronomic research. WeedSmart Phase 3 builds on the strong and effective brand established in Phases 1 and 2 by continuing to work with growers and industry to increase awareness and to provide solutions to keep herbicides working. The WeedSmart campaign ensures that the latest information and practical solutions reach grain growers as quickly as possible. WeedSmart continues to promote practice change on farm by providing growers and advisers with well researched management strategies to curb the impact of resistance and, therefore, increase the sustainability of available chemicals. Results: HWSC is a common topic covered by various WeedSmart platforms. For example: • HWSC Tools – on-line training modules (https://weedsmart.org.au/resources/hwsc/) • Farmers share their harvest weed seed control experiences with Planfarm agronomist Dani Whyte (https://weedsmart.org.au/podcasts/farmers-share-their-hwsc-experiences-with-planfarm-agronomist-dani-whyte/)

	• Harvester set up for harvest weed seed control (HWSC) for all header colours (https://weedsmart.org.au/webinars/harvester-set-up-for-harvest-weed-seed-control-hwsc-for-all-header-colours/) Comparing the iHSD + Seed Terminator (https://weedsmart.org.au/webinars/comparing-the-ihsd-seed-terminator/)

Issue No. 42 - Crop establishment under marginal soil conditions – moisture, stubble, precision seeding, discs, chemicals

GRDC investments addressing this issue

Optimising plant establishment, density and spacings to maximise crop yield and profit in the southern and western (UOA1803-009RTX))	Particular interest has been shown in the potential of precision planting and singulation to reduce seeding rates and seed costs in crops such as hybrid canola where seed costs are high. This investment aims to determine current levels of crop establishment and stand uniformity in the major winter crops, the potential for improvements in crop establishment and the potential agronomic and economic benefits of improving crop establishment and stand uniformity within modern farming systems. While precision seeding may be seen as a 'gold standard' in improving stand uniformity, there may also be significant gains to be achieved by improving the operation of conventional seeders. Involvement of prominent grower groups with experience in seeding systems research will ensure that the project will maintain a strong grower focus and deliver relevant information to growers in the regions. The project will has three main components which show a clear pathway of delivery of the project outputs: (i) A survey of commercial crops and grower practices will provide a baseline of current levels of establishment and identify the factors that are most influential in determining variation in crop establishment and uniformity. In the southern region this will include paddocks from all three constituent states – SA, Victoria and Tasmania. Interviews with leading growers will help identify gaps in knowledge and highlight issues that need to need to be addressed when adapting precision seeding techniques to winter cropping. The suppliers of the precision seeding equipment have been contacted to provide machinery for large scale side-by-side demonstrations at prominent sites in WA, SA and Victoria. This first phase will help inform future experimental work. (ii) A program of field work involving a mix of small scale plot work and large scale trials with commercial equipment will examine important aspects of seeder set up, agronomic inputs and soil conductions in the performance of different seeders. An important aspect of this work are field experiments on machinery performance under different conditions. The aim of this work is quantify the effects of these factors to provide recommendations to growers and to assess the agronomic and economic benefits and risks of different seeding systems. (iii) A communication program will be developed to highlight the results of the survey and to develop case studies, guidelines and instructional videos for growers. The results and key messages from the experimental program will form the basis of the communication program. The results of the project will be reviewed at annual project meetings and feedback will be sought from the advisory committee.
Canola Establishment – survey and literature review (BLG110) [NSW strategic Partnership]	The aims of this one year project are to – (1) Undertake a literature review on canola establishment, with the purpose of identifying research gaps and providing key recommendations for future research. The literature review will include both scientific and grey literature. (2) Conduct a field survey across 90 commercial paddocks in central NSW, with the primary purpose of evaluating current canola establishment rates and uniformity of plant spacings. The secondary purpose of the survey is to evaluate management trends that affect canola establishment, such as stubble management (burnt, retained or cultivated), seeding system (disc, knifepoint/press wheels, scatter bar/prickle chain), fertiliser (rate, source and placement) and seed type/source/size/sowing depth. The combination of the literature review and survey will ensure future research is well informed and targeted. The literature review will enable clear hypothesis development for a potentially larger investment in year 2-5 of the bilateral, whilst the survey will provide a current benchmark of field establishment and uniformity of plant spacing's in current farming systems.

Improving crop emergence through the better use of seeding technologies (WMG1802-001SAX)	Timely emergence of crops is a key driver of grain yield for growers. While this is largely influenced by seasonal conditions and the timing of the break to the season, the selection of seeding equipment can also have a large impact on the establishment of crops. The use of paired row seeding configurations has been adopted by many farmers in WA to as a tool to improve crop competition with weeds, but there is anecdotal evidence that this approach can lead to a reduction in the timely emergence of crops due to inappropriate placement of the seed into the soil. In seasons where there is low or variable rainfall, paired row seeding can lead to the seed being placed in the dry sidewall of the crop-row furrow, away from the seed row. Conversely, single row seeding can place the seed in the bottom of the seed-row furrow where the soil can dry rapidly and reduce timely crop emergence, indicating that seeding configurations must be matched to the soil type This project will investigate the impact that seeding configuration has on the timely emergence of crops to grain growers in Western Australia across a number of differing soil types. Demonstration sites will be established across the Northern Agricultural region of WA to test the impact of shallow and deep seeding techniques with single and paired row seeding configurations. The key outcome for this project will be to measure the emergence of crops at 14 days following seeding to indicate the effectiveness of the seeding configuration to improve crop establishment. The outcomes of this project will give greater confidence to grain growers to identify the seeding configuration that is appropriate for their soil type and rainfall environment that will maximise the 14-day emergence of crops, and contribute to an improvement in grain yield.
A Review of Seeding Systems that Provide Improved Crop Establishment for Growers in the Western Region (CMP1802-002SAX)	Germination and establishment of crops play a critical role in the overall success of a cropping program, particularly in dry or marginal soil moisture. Growers believe that in 2017, apart from moisture, seeding systems had the biggest impact on whether or not a crop emerged well. The Kwinana West RCSN has therefore nominated seeding equipment as a priority focus area, particularly investigating which seeding equipment enables good crop establishment in dry conditions, especially for small seeded crops. The end result of the project will be a booklet titled: Seeding Systems. Case Studies of Growers in WA: An Initiative of the Regional Cropping Solutions Network. It will feature at least 25 case study participants (five per zone) who use varying seeding systems. Importantly, CussonsMedia will extend the outcomes of the project to relevant stakeholders across the Western Region port zones by working with local grower groups and our broader agricultural network.
Seeding systems to improve cereal crop establishment on heavy textured soils (CFG1802-001SAX)	This project will demonstrate to growers the most profitable tyned seeding system for improved cereal crop establishment on medium to heavy textured soils in the eastern wheatbelt. This will be achieved by establishing a trial site to assess a range of furrow closing options (4) and down force pressures (2). The results will be compared to standard practice of growers within the region. The project aims to highlight the need to select the best furrow closing system on heavy textured soils to improve crop emergence and grain yields. Taking a more than single year approach will account for varying seasonal conditions.
Managing early season canola establishment pests in New South Wales – Development of technical content (CES1810-001SAX + FLR1810-001SAX)	The Service Provider is responsible for: • The development of technical content • Workshop materials • The evaluation of the investment Providing support to FarmLink Research Limited (FLR1809-001SAX) regarding the delivery of technical content. Key resources developed include: • A Best Management Practice Guide in the form of interactive .pdfs • Webinars targeting pests of interest to north, central and south NSW canola growers • Evaluation materials, which will follow the MAKAT model interrogating grower Motivation, Attitude, Knowledge, Ability and Technology
Validation of the persistence of common residual herbicides being used across the low rainfall zone under	This project can be divided into 3 main objectives: 1. Provide a summary of the existing literature relating to the persistence of herbicides in sandy soils under low rainfall conditions 2. Identify and monitor paddocks through linking with growers and agronomists that utilize summer weed control practices which may lead to herbicide residues in the soil with the potential to impact

current farming systems (which are dominated by stubble retention and no-till crop establishment) and to develop techniques (DAS00162-B)	subsequent crops 3. Conduct a glasshouse trial using intact cores of sand soils collected from the SA and Victorian Mallee to identify how high rates of glyphosate, 2,4-D and mixtures of the two herbicides affect early growth of wheat, lentils, canola and medic following different simulated rainfall regimes of decile 1, 5 and 9. Herbicide use has increased in the low rainfall zone in recent years due to the adoption of conservation tillage, continuous cropping and an increasing emphasis on weed control in summer fallows to preserve stored water. Farmers and consultants are concerned about the persistence of herbicides in soils and the potential negative impacts of these residues on cereal and break crops. High costs and difficulty interpreting results mean that the vast majority of farmers do not conduct herbicide residue testing on a regular basis. The small scale paddock survey of broad acre farming systems across Australia detected residues of glyphosate (and its metabolite AMPA), trifluralin and diflufenican in the majority of paddocks sampled at agronomically significant levels before seeding. However, detections of Group I herbicides were somewhat less frequent. Extrapolating results of this kind, or translating small-scale laboratory dose-response trials to practical recommendations for farmers is extremely difficult

Issue No. 10 - The risk (either perceived or real) of herbicide residues accumulating in sandy soils in low rainfall environments is reducing returns.

Herbicide residues appear to be persisting longer than label indications, particularly on sandy soils. The evidence for this is anecdotal and creating uncertainty. There may be low level yield losses and reduction in returns or on the other hand, the perceived risk may be leading to decisions that reduce returns. The situation needs to be clarified.

<u>GRDC investments addressing this issue</u>

Benchmarking and managing soil herbicide residues for improved crop production (DAN00180)	To benchmark the risk of soilborne herbicide residues to crop production, including indirect effects on soil function and direct plant-back risks. To develop models and monitoring tools to assist farmers and agronomists in managing herbicide residues in soils. Anecdotal evidence also suggests that plant-back damage in rotational crops due to herbicide residues is a growing concern amongst growers, but the scale and cost to the Australian Grains industry remains unknown. This project will benchmark level of herbicide residues in cropping soils and generate new knowledge about the fate, behaviour and risk of herbicides to productivity. This will enable the Australian grains industry to better understand the risks and implement changes in management for more productive and resilient farming systems. A review of over 340 peer-reviewed articles found that there is little evidence for consistent, long-term impacts to soil (microbially mediated) functions caused by herbicides when used at registered label rates. Some site-specific exceptions include the interaction of sulfonylurea herbicides with certain pathogens (e.g. Rhizoctonia) on alkaline soils to increase disease risks and inhibit N-cycling processes. Controlled laboratory experiments screened the impacts of 6 different herbicides on soil enzyme activities and N-cycling in 5 different soil types and confirmed that effects are minimal at up to 5 times label rate application. Metsulfuron-methyl had significant but minor impacts (<25% of control level) on nitrification in 3 of the 5 soils tested (impact on 2 alkaline soils and 1 low OM soil). Two nationwide field surveys across in 2015 and 2016 determined baseline levels of herbicide residues in Australian grain growing soils prior to sowing. The dominant residues in both surveys (in terms of detection frequency and residue load) were the herbicide glyphosate and its breakdown product AMPA, plus the herbicides trifluralin and diflufenican. Relatively high levels of triasulfuron and diuron were also found in some regions. Plant bioassays have been conducted to determine the risk of these herbicide residues on crop growth and symbiotic associations (rhizobia in legumes for biological N2-fixation). A new model to predict herbicide persistence in soil has been developed and validated in conjunction with a rapid, inexpensive Quicktest™ to quantify atrazine residues.
Management of residual herbicides in broadacre cropping (THA00001)	Summary of past work and gap analysis for southern region; Extension to increase awareness: • Residual herbicide behaviour in soils • Residual herbicide breakdown mechanisms • Effect of seasonal conditions on persistence • Likely high risk situations

	• Farming systems interactions • Collated plant back summaries for residual herbicides • Risk assessment matrices to enable anticipation of potential problems as farming systems evolve. Gaps: • Sandy soils and impact on residual herbicide persistence; • IMI- impact of residues on conventional crop yields compared to tolerant varieties across a range of soil types; • IMI-retrospective analysis of Intervix plant back trial data held with BASF and NuFarm to refine label requirements; • IMI-promotion of strategic use of IT technology; • Clopyralid (Lontrel) behaviour in soils in the context of modern farming systems; • Lentil variety development- dicamba tolerance and improved IMI tolerance; • Alternate herbicide use options to Clopyralid and 24 D amine) Recommendations: • Package up simple messages for farmers and more detailed background information for advisors addressing the gaps • Annual production of plant back summaries with company updates or amendments. • Targeted field trials for specific regional issues as above. • Herbicide plant back working group to advise on the content and format for message delivery for a response package and oversea the outcomes of field work. • The use of extension methods that cater to the varied learning preferences of farmers and advisors including but not limited concise fact sheets, on-line resources and field based training exercises. Comments: GRDC working with companies to address some of these gaps. Need to address liability.
DAS00162-B - Validation of the persistence of common residual herbicides being used across the low rainfall zone under current farming systems (which are dominated by stubble retention and no-till crop establishment) and to develop techniques (2016-2019)	The project can be divided into 3 main objectives: 1. Provide a summary of the existing literature relating to the persistence of herbicides in sandy soils under low rainfall conditions 2. Identify and monitor paddocks through linking with growers and agronomists that utilize summer weed control practices which may lead to herbicide residues in the soil with the potential to impact subsequent crops 3. Conduct a glasshouse trial using intact cores of sand soils collected from the SA and Victorian Mallee to identify how high rates of glyphosate, 2,4-D and mixtures of the two herbicides affect early growth of wheat, lentils, canola and medic following different simulated rainfall regimes of decile 1, 5 and 9.

Issue No. 33 – Sandy soils – crop establishment and growth

GRDC investments addressing this issue

Increasing production on sandy soils in low and medium rainfall areas of the southern region (CSP00203)	Sandy soils are a valuable production resource in the cropping regions of Southern Australia, accounting for 5 Mha of the land cropped in the region. A large gap between actual yield and water limited yield potential on sandy soils in the low rainfall cropping zone of south-eastern Australia has been identified as have opportunities for the management for the constraints to productivity using combinations of mitigation and amelioration strategies. In order to support growers with problem sands to consider trialling practices to overcome the constraints to crop water-use we will provide a framework for them to: 1. Identify problem sands 2. Identify the primary constraints to crop water use and their relative impact 3. Identify treatments to address constraints 4. Identify funds, skills and equipment required to trial potential practice changes 5. Measure the success of each practice

	6. Identify the most useful timing and extent of implementation on-farm. As a result, a R & D effort to deliver this outcome is planned to establish the nature and extent of the constraints, to measure the degree to which the problem controls the yield gap between yield attained and yield potential and to develop appropriate and cost-effective management strategies with robust estimates of return and risk of investment. In order to deliver a consistent approach we will define a constrained sandy soil as one where the constraint to crop root exploration occurs within the sandy layer and the treatments explored will focus on mitigation and/or amelioration of the constraints within this sandy layer.
AGG00002 - Growing high yielding crops on sandy soils° (Completed 2017)	Outcomes: 1. Evaluate the effect of various forms of cultivation, with and without lime and manures, on crop growth, yield and grain quality of wheat on sandy soils; 2. Evaluate the effect of various crop nutrition treatments and rates, including nitrogen, phosphorous, sulphur, potassium, zinc and manures on crop growth, yield and grain quality of wheat on sandy soils 3. Evaluate variety performance and the effect of seeding rate on crop growth, grain yield and quality of wheat on sandy soils 4. Measure the impact of various pre-emergent herbicides on crop growth, yield and grain quality of wheat on sandy soils Research: The trials were designed to measure the effect on crop growth, grain yield and grain quality of the four main management factors impacting on sandy soils. Although any management practice that increases biomass (often measured by NDVI) increases yield in sandy soil, cultivation, nutrition, variety and herbicides were the factors identified as having the biggest effect.
GRANT: A holistic approach to seep management for preventing land degradation in the landscape (MSF1812-002OPX)	The National Landcare Program aims to protect, conserve and provide for the productive use of Australia's water, soil, plants and animals and the ecosystems in which they live and interact, in partnership with governments, industry and communities. Protecting and restoring our soils, water, vegetation and biodiversity underpins the productivity and profitability of agriculture, fisheries and forestry industries and will assist these industries to become more resilient and able to effectively respond to changing climate, weather and market conditions (such as the need to demonstrate environmental credentials to access markets). Sandy seeps have become a significant issue on the dune-swale landscapes in the dry areas of SA and Victoria, making productive farming soils saturated, untrafficable, and weed infested, eventually becoming saline and prone to erosion. Seeps have become more evident in the last decade, due to farming system changes coupled with high rainfall periods. Farmers identify that poor crop water use on the sand dunes along with effective summer weed control and greater retention of soil moisture has led to the expansion and formation of seeps lower in the landscape. This NLP project led by Mallee Sustainable Farming aims to apply a 'tool box' approach to seep management by: 1. Using new and existing remote sensing tools to identify areas at high risk for seep expansion; 2. Preventing seep formation by demonstrating high water use options for different systems; 3. Categorising seep severity and applying the best treatment options to remediate the seep area.

Issue No. 36 – Fertiliser toxicity

<u>GRDC investments addressing this issue</u>

UQ00086 - Fertiliser form and soil interactions when applied in high concentration bands – Post-Doctoral Fellow aligned to UQ00063	As reliance on fertilizer grows and an increasingly complex mix of nutrients are required to achieve water limited yield potentials, the interactions between product choice, fertilizer placement, moisture dynamics and crop acquisition are increasingly determining the profitability of fertilizer decisions. Recent examples include the demonstrated need to place phosphorus (P) and potassium (K) deeper in the soil profile, to address nutrient depletion in subsoil layers where prolonged root activity and nutrient acquisition occur but where nutrient replenishment is limited. GRDC has substantial current investments quantifying crop responses to applications of P and K fertilizers into the depleted subsoil layers (UQ00063) and the residual value of those deep applications (UQ00063 extension); optimizing the P and K application strategies, working with issues such as rate*band spacing interactions, the degree of soil disturbance required during deep placement and the

	pros and cons of liquid and granular formulations (UQ00078); and developing soil test-crop response relationships to fill gaps for less well researched combinations of crops and nutrients in the Better Fertilizer Decisions for Cropping database (UQ00082). These projects are all strongly focussed on testing crop responses under field conditions in growers fields, and distributed across the major production centres in Qld and NSW (in addition to Vic and SA in the case of UQ00082). Whilst there is considerable field research activity addressing the issues of placement of P and K, there has been very little mechanistic research into the fertilizer – soil interactions that underlie effective application strategies. Specific questions are arising around the most effective form of P fertilizer to maximize P bioavailability in the short and longer term (e.g. mono-calcium and mono or di-ammonium phosphates – MCP, MAP and DAP, respectively) when applied in bands in soils with differing clay contents, pH, P sorption capacity and Ca status. Anecdotal evidence from UQ00063 has suggested that MCP may only be effective as a deep P source in specific soil types, but ineffective in others. While MAP seems to be providing more consistent benefits, little work has been undertaken with other P sources or forms (e.g. liquid formulations such as ammonium polyphosphate or MAP suspensions). The limited previous research published in the literature that has investigated fertilizer reaction products has generally focused on single soil types. However, our field evidence demonstrates that the fertilizer behaviour and availability varies markedly between soils – the current research will address this important knowledge gap. Industry need clear guidelines on the suitability of different P products for use in specific soil types, and that information requires a more in-depth understanding of the soil-P fertilizer interactions in key soil types. The other emerging research gap also involves banded fertilizer applications, but in this instance is focussed on understanding the interactions between fertilizer products when applied in mixtures at high in-band concentrations. This is particularly relevant when deep bands are being applied in fields to address multiple nutrient deficiencies (e.g. of P and K), when growers are using P- or N&P- enriched K bands to encourage root proliferation and enhance crop recovery, or when growers are combining N applications with deep P/K banding to reduce the number of passes during fertilizer application. There are already examples from UQ00063 where the addition of KCl to deep-banded MAP/ammonium thiosulphate blends resulted in the complete elimination of substantial P and S responses in the year of application and a subsequent crop season. Improved guidelines for growers, advisors and the fertilizer industry on the limitations of potential co-location of nutrients in concentrated bands will rely on an improved understanding of the mechanisms driving such responses.
BFDC - Making Better Fertiliser Decision for Cropping Systems in Australia, phase 3 (DAN1806-004RTX)	Fertiliser input costs are the largest single variable expense for grain growers, comprising up to 25 % of variable costs per annum. Despite the expense, fertiliser decisions made by grain growers do not always rely on soil test knowledge as part of a suite of knowledge sources contributing to a rate recommendation. This reflects a significant level of scepticism among some grain growers and advisors that soil testing does not explain crop response, that the recommendations provided using a soil test are flawed due to biased data, or both. The Making Better Fertiliser Decisions for Cropping Systems in Australia project (BFDC) (DAN00132) sought to address this challenge. In this project, all available public and private soil test-crop response data that could be found from across Australia were collated for nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) use in cereals, oilseeds and pulses. These data were stored in a single central repository for access by approved users through an online query tool, the BFDC Interrogator. The BFDC Interrogator is used to derive soil test-crop response calibration relationships and critical soil test values based on specified criteria (e.g. a cropping region or soil type). The soil test-crop response data held in this repository are recognised by the Fertiliser Industry Federation of Australia's Fertcare® program as the 'best available' data set in Australia. In order to maintain their Fertcare accreditation, fertiliser companies and agribusiness advisors must use best available data in order to formulate fertiliser use recommendations. The development of the BFDC Database and BFDC Interrogator as 'live' online resources represents a very significant step forward for fertiliser recommendations in Australia. No longer will subsets of data be used as part of recommendations without knowledge of the other data available. Instead soil test-crop response relationships can be derived from a large body of trial data using a series of identified and agronomically valid filtering tools (e.g. the use of Phosphorus Buffering Index to interpret Colwell P tests). Another very significant finding from BFDC was the dearth of knowledge that exists for crops other than for wheat, barley and canola nationally and for lupins in Western Australia. There also tends to be limited trial work for K and S across all crops. To further complicate the development of soil test-crop response calibration relationships, many trials

	have inadequate data and so could not be included in the database. While traditional single season nutrition rate experiments are still being undertaken, some of the more significant trial work is tending to address long term applications of nutrient(s) and their subsequent impact on plant nutrition. A further investment in BFDC needs to account for the collation of new response work conducted in the traditional manner, but also needs to address the inclusion of other relevant trial data (e.g. suitable long term trials) and their use in association with traditional single season trials for the determination of soil test-crop response calibration relationships and critical soil test ranges for cereal, oilseed and pulse crops. The GRDC More Profit from Crop Nutrition phase 2 (MPCN II) initiative provides the opportunity for trial data to be collected that address some of the knowledge gaps within BFDC. It is thus the role of Making Better Fertiliser Decisions for Cropping Systems in Australia phase 2 (BFDC II) to address the challenge of both collating these new data (single season and other trials) and subsequently using these data within the BFDC Interrogator to derive N, P, K or S soil test-crop response calibration relationships for different grain growing regions in Australia. BFDC II is also seeking to: 1. Provide advisers and researchers from across the grains and fertiliser industries with ongoing access to the BFDC Interrogator for the purpose of developing and reviewing soil
Seed Calculator	Existing IPNI information and guidelines http://seed-damage-calculator.herokuapp.com/

Issue No. 42 – Understanding seed zone environment – vertical furrows – need confirmation

GRDC investments addressing this issue

Optimising plant establishment, density and spacings to maximise crop yield and profit in the southern and western (UOA1803-009RTX))	Rapid and even crop establishment is a foundation of vigorous and high yielding crops that are competitive against weeds. In recent years there has been growing interest in Australia and overseas in adapting precision seeding technology that is widely used in summer crop production, to winter crops. Particular interest has been shown in the potential of precision planting and singulation to reduce seeding rates and seed costs in crops such as hybrid canola where seed costs are high. However, there is little information at present on the current levels of crop establishment and stand uniformity in the major winter crops, the potential for improvements in crop establishment and the potential agronomic and economic benefits of improving crop establishment and stand uniformity within modern farming systems. While precision seeding may be seen as a 'gold standard' in improving stand uniformity, there may also be significant gains to be achieved by improving the operation of conventional seeders. To address these issues, this proposal has been developed collaboratively by grower groups in the southern region (Hart, BCG, SFS, NSS), WANTFA (with the collaboration of the Liebe, Facey and Corrigin Farm Improvement groups), the University of Adelaide and the University of SA. It brings together a range of complementary skills and experience and provides a strong network of grower groups to deliver information and guidelines on the value of improvements in crop establishment and stand uniformity to improved yield and profitability. The involvement of prominent grower groups with experience in seeding systems research will ensure that the project will maintain a strong grower focus and deliver relevant information to growers in the regions. To help guide the project, an advisory committee with representatives of the participating organisations, the GRDC and leading growers and advisors from the two regions will be established. The project will have three main components which show a clear pathway of delivery of the project outputs: (i) A survey of commercial crops and grower practices will provide a baseline of current levels of establishment and identify the factors that are most influential in determining variation in crop establishment and uniformity. In the southern region this will include paddocks from all three constituent states – SA, Victoria and Tasmania. Interviews with leading growers will help identify gaps in knowledge and highlight issues that need to need to be addressed when adapting precision seeding techniques to winter cropping. The suppliers of the precision seeding equipment have been contacted to provide machinery for large scale side-by-side demonstrations at prominent sites in WA, SA and Victoria. This first phase will help inform future experimental work.

	(ii) A program of field work involving a mix of small scale plot work and large scale trials with commercial equipment will examine important aspects of seeder set up, agronomic inputs and soil conductions in the performance of different seeders. An important aspect of this work are field experiments on machinery performance under different conditions. The aim of this work is quantify the effects of these factors to provide recommendations to growers and to assess the agronomic and economic benefits and risks of different seeding systems. (iii) A communication program will be developed to highlight the results of the survey and to develop case studies, guidelines and instructional videos for growers. The results and key messages from the experimental program will form the basis of the communication program. The results of the project will be reviewed at annual project meetings and feedback will be sought from the advisory committee.

Maximising water use and profit across the crop sequence

<u>GRDC investments addressing this issue</u>

National Paddock Survey Initiative (BWD00025)	Consultants and grower groups are working with grain producers in all grain growing regions to quantify the yield gap between actual and water-limited potential yield. Detailed monitoring of 250 paddocks over a four year rotation will identify the main yield constraints and develop amelioration practices to profitably close the yield gap. Annual paddock monitoring includes: • Soil water and soil chemistry at sowing and harvest • Soil borne disease monitoring using PredictaB • Paddock history (crop types, inputs, yield) • In-crop monitoring of crop growth, weeds, insects and diseases • Paddock management – sowing date, cultivar, inputs, in paddock temperature during flowering/grain filling • Yield mapping to identify low and higher yielding parts of the paddock CSIRO are responsible for analysing monitoring data and undertake the yield gap analysis. Results will increase the understanding of interactions between different constraints limiting yield and help optimise agronomic decisions to assess production potential and manage risk.
Improving the profitability of pulse production through local validation of research outcomes in the Southern Region (DAV00150 – validation component)	A targeted validation trial program of significant scale to deliver local data and knowledge for the development of pulse crops suitable to areas across the southern region where research and development is limited. In collaboration with the Southern Pulse Agronomy project (DAV00150), pulse crops and constraints will be prioritised for each agro-ecological zone to develop the focus of the validation program. For example, it is envisaged that up to four of the most important pulse crops and up to four constraints will be examined in each zone where gaps exist. Local biophysical data from the validation trials and their impact on crop management, farming systems and farm economics will be made publicly available. The validation trial data will feed back into research and development activities of the Southern Pulse Agronomy project, and new knowledge will flow into the pulse extension project (PROC 9175825). In partnership with these and other GRDC projects, this three and a half year investment, starting early 2018, will deliver greater knowledge of the pulse phenotypes suited to each agro-ecological zone and management practices to optimise their production and profitability. Expected outcome, by June 2021, grain growers, advisers and industry will have access to local trial data that address the main constraints to the production of key pulse crops in each agro-ecological zone across the southern region. These data will quantify the adaptation and performance of key pulse crops in each zone, and the benefits of traits and management practices providing adaptation to local environments and farming systems, and enduring profit. These data and supporting economic analyses will contribute to grower and advisor confidence in pulse production, and will inform optimum agronomic practices for specific pulse phenotypes through evaluation of their applicability, profitability and risk in local environments.
Profitable crop	Trial and demonstration activities showed that wheat preceded by a two year break yielded better than

sequencing in the low rainfall areas of South Eastern Australia (DAS00119) Completed 2017	continuous wheat, by at least 0.5 and to more than 1 t/ha in the first year following the break and by up to 0.5 t/ha in the second subsequent crop. Any break combination which substantially reduced the major constraints to wheat production, resulted in large yields benefits - these constraints were mostly grassy weeds but rhizoctonia and low N fertility was also factors. Gross margin comparisons show that 2 year breaks can be as profitable, and sometimes even better, over 5 years than continuous wheat, providing at least one of the break years produced a reasonable profit. One year breaks resulted in improved wheat production but grassy weed levels built again quickly. Continuous wheat became increasingly expensive to manage as low N fertility and building grass pressure demanded higher inputs. Microbial health was highest in those sequences which had a vigorous, legume-dominant pasture and poorest where a fallow had been included. Two years of diverse cropping options was not sufficient to change the frequency of N-fixing or nitrifying genes in the soil bacteria, except for fallows usually causing a decline. Results from this project show the benefit from the measurement of microbial biomass, N mineralization potential and nitrifying organism populations for better understanding of rotation effects in different soil environments. APSIM simulations based on data from four of the core sites estimated that the yield of field peas and canola would be 47-73% and 49-67%, respectively, of wheat under the same conditions. This relationship did not hold in high yielding seasons, probably because APSIM poorly simulates the impact of heat and frost on grain yields, especially for break crops. Risk analysis of field pea and canola performances developed through APSIM showed that while gross margins for these two break crops are favourable relative to wheat, they are more risky and more variable options.
Facilitating increased on-farm adoption of broadleaf species in crop sequences to improve grain production and profitability (aka 'crop sequencing' project) (CSP00146)	Research was undertaken in partnership with 7 grower groups across the southern region to determine whether production risks associated with difficult to manage grass weeds, or management of soil N, in cereal-based systems could be profitably addressed using legumes or brassicas break crops. Trials showed that: 1. the profitability of break crops was either similar to or greater than wheat, 2. sequences including at least one break crop were more productive and profitable than continuous wheat when using best management practices, 3. the cost of controlling herbicide-resistant grass weeds in continuous wheat systems was more expensive and less effective than alternative options available in break crops, and 4. rates of N fertiliser after legumes can be reduced to meet target grain yield and quality. The expected economic outcome includes improvements in the stability of grain production and system profitability, reduced costs and risk of production. The increased diversity of crop species grown also causes improved water and nutrient use by more vigorous cereal crops grown after break crops resulting in a reduced risk of deep drainage, nitrate leaching and greenhouse gas emissions, and lowered rates of soil acidification and salinization.
Validating recent research on break crop options in the low rainfall zone to determine the best options for the different climate, soil type and biotic stress situations (DAS00162-A)	The aims of this investment - 1. Summarise recent studies on break crop options in the published and grey literature; 2. Determine the best break crop options for different climate, soil type and biotic stress situations; 3. Develop improved agronomic packages to manage biotic stresses, and 4. Extend the information generated to growers and advisers
Legume management for economic nitrogen production in the low rainfall areas of North West Victoria (VIS00002)	The project will run a trial to determine the residual nitrogen benefits and the overall economics of the various management practices with pulse/legume crops. The trial will consist of Field Peas and Vetch and the different systems or management options for these crops. The management systems or end use to be trialled will include Grain, Hay, Brown Manure and Green Manure compared to a Chemical Fallow and a continuous Wheat rotation. The trial will run for 3 years. We aim to answer the following questions that are often raised by farmers in North West Victoria. How much Nitrogen does the end use of the pulse crop add to the system? When does this nitrogen become available to following crops? What are the economics of the various management options? How much moisture is conserved in the various management systems? The trial will address:

	1. The economics of pulse produced N v buying N in a bag. 2. How much of the above ground estimated N find its way back into the soil or system?
Identifying the key production and profitability drivers using commercial paddocks (POO0001)	This project aims to utilize actual grower paddock records and data to identify the key drivers to their production and subsequent profitability in the Victorian Mallee during 2014-2016. The 2014, 2015 and 2016 seasons were of particular interest to growers and advisers as they each presented various challenges that were not faced before. In 2014, growers experience an excellent start to the season, before being faced with Green Peach Aphid in canola, severe frosts in August which led to stem frost in wheat and the development of El Nino which inevitably led to a very dry spring. This work has supported what the industry has previously believed and can provide confidence to growers and advisers that the trends are representative. It was evident throughout the data collection process that production data and specific application information is still poorly kept by growers. Whilst this project has somewhat confirmed what growers and advisers were seeing, it hopefully can illustrate the value of growers keeping good records and sharing, to compare across a region.
Measuring and managing soil water in Australian agriculture (CSP00170)	This project expand upon the soil characterisation and monitoring activity in the western, southern and northern cropping regions, and further enhanced the knowledge and skills of growers and agri-consultants in characterising the plant available water capacity (PAWC) of their soils to inform soil water management. This was achieved through discussion of soil properties, including sub-soil constraints and exploration of farming system options using decision support tools informed by locally relevant soil water and climate information.
New tools to measure and monitor soil moisture (USQ00014)	Soil Water App (SWApp)uses a tested water balance model and inputs from- • weather data from a nearby Bureau of Meteorology; • rainfall from your local rain gauge; • rainfall from a Bluetooth enabled rain gauge (10m range); • soil descriptions suited to local conditions; and • soil and crop cover conditions for each paddock. This input will estimate infiltration, runoff, evaporation, transpiration and deep drainage to estimate soil water on a daily basis. SWApp uses long-term weather data to provide a forward-looking estimate of outcomes. Data is securely stored in the cloud and can be accessed from multiple devices.
Re-engineering soils to improve the access of crop root systems to water and nutrients stored in the subsoil. (DAW1902-003RTX)	This investment will address multiple interacting soil constraints within the crop root zone through strategic combinations of soil amelioration techniques or from soil profile re-engineering. Soil profile re-engineering is the fundamental redesign of soil profiles to achieve dramatic improvements in critical measures of cropping performance including water and nutrient use efficiency, grain yield and grower profitability. Soil amelioration has predominantly been adopted on deep sands and sandy earths with more limited adoption on sandy gravels and texture contrast soils. The 4.8M ha of sandy texture contrast soils present particular challenges as they can have a layering of both sandy and heavy-textured soil constraints and depth to the clay B-horizon can be highly variable. Developing diagnostic and targeted amelioration packages for these soils represents a substantial opportunity to dramatically improve grain production and profitability. The project will do this through: 1. Identifying the most profitable and long-lasting soil amelioration and amendment strategies for managing multiple interacting soil constraints. 2. Re-engineering the soil profile through a combination of deep soil loosening; reconstituting profile layers and deep placement of nutrients and soil amendments. If soil re-engineering could overcome the 1.0-1.4 t/ha yield gap (van Gool 2011) on 20% of the 12 M ha this would equate to a further $600-$840 million per year in yield benefits that would flow directly to grain growers. 3. Extension and upgrade of the recently released Ranking Options for Soil Amelioration (ROSA)

	financial model (Petersen et al. 2018) to incorporate the economics and benefits of re-engineering will be a primary output of this project. This tool is essential in helping growers understand the costs and benefits of soil amelioration and re-engineering strategies. Our current agronomy and farming systems research has been limited by often being undertaken on constrained soil or soils where only a single soil constraint has been addressed. Innovative high-risk soil re-engineering will provide a new increased yield potential that will underpin new agronomy and farming systems research in the future.
Managing the fallow period for optimum water use and nitrogen availability – 2005 to 2008 (CSO232)	This project aims to – 1. evaluate the effect of fallow management on soil water storage and evapotranspiration during the non-growing season following crops grown as part of the cereal rotation in southern Australia; 2. determine the effect of management on the rate of stubble decomposition and nutrient release, 3. develop fallow management strategies that minimise deep drainage without detrimentally affecting the subsequent crop by limiting water and nitrogen availability
Improving farming system efficiency in southern NSW (CFF00011)	To develop strategies to: • convert rainfall into more profit across a crop sequence • while managing soil fertility, weeds, diseases and costs Australian grain-growers have been enthusiastic adopters of crop benchmarking tools such as the French and Schultz water use efficiency (WUE) benchmark to compare the performance of individual crops with predicted water-limited potential. However less work has focussed on the efficiency of an entire crop sequence, where the legacies of water, nitrogen, weeds and diseases act over time to influence the productivity, efficiency and sustainability of different crop sequences. Recent studies in the northern region suggest that the efficiency gap at the sequence level is even greater than that at the crop level, providing significant opportunities to develop systems and practices that increase system efficiency and profitability. In the few studies available to date in the GRDC northern region, the average annual gross margin of the best crop sequence is often $150 to $250/ha higher than the most common crop sequences, but the performance with respect to water-limited potential is not known. This project focussed in southern NSW will work closely with existing farming systems projects in the northern area to (i) review the current cropping system efficiency in southern NSW to identify the key drivers of efficiency and profitability (ii) conduct field experiments and linked simulation modelling studies to assess the impacts of different sequence and management strategies on system efficiency, profitability and sustainability and (iii) develop robust regional recommendations that account for economic, climate and price risks, and the long-term sustainability of the cropping system. Our goal is to have 50% of growers in the northern region achieving more than 75% of the water-limited system efficiency.
Optimising whole-farm water use efficiency and risk using whole farm bio-economics (CSP00208) Postdoctoral Fellow aligned to Northern farming Systems projects (CSP1707-019RTX)	The overall objective of this project is to increase the speed and level of adoption of new system innovations that improve farm efficiency by better demonstrating implications of paddock-scale modifications on whole-farm profit and risk. As Australian farms become larger, with more intense crop production, timeliness of operations, managing risk exposure to the whole farm business becomes increasingly influential on agricultural practices and involved considerations of labour force, debt, equity and human capacity. Opportunities to impact whole farm performance are missed if agricultural research does not look beyond simply maximising production or gross margins at the paddock scale. In this project, a Postdoctoral Fellow will be embedded within the teams conducting an existing paddock-scale experimental program across the northern region to use whole-farm bio-economic approaches to improve the understanding of how whole-farm considerations, (equity, debt, labour, machinery, and social factors) impact on potential for farms to maximise their system water-use-efficiency. Whole-farm bio-economic analyses are required to evaluate the whole farm impact of new component innovations on farms of different structure and agro-ecological situation, evaluate the likely extent of use of a practice at the farm level and the consequent impact at a regional level. Tools such as MIDAS have been used valuably over a long period, but the demands of these economic tools have limited their use and

	engagement. A suite of other tools have been developed for particular purposes but don't always have the capacity to adequately account for the complex farm labour-resource-enterprise interactions that drive farm-level performance and risk. We aim to ensure that valuable agronomic innovations emerging from paddock-scale experimental work and associated modelling are thoroughly assessed at the whole-farm level, so the most promising strategies can be more rapidly identified and adopted, and tractable farm-scale constraints to other promising innovations can be identified and if possible removed.
A long-term study to increase water use efficiency, grain yield and the profit of growers in the Western Region in a no-till system (UWA00174)	This long term trial was started in 2007 and was based on the 2005 "Derpsch report", which concluded that improved soil organic carbon, crop yield and water use efficiency could only be achieved with a systems approach that included full stubble retention, diverse rotations with cover crops and a more holistic approach to weed management. The trial has tramlining with 2 cm accuracy guidance on the seeding machinery. The overall objective is to determine the benefits of high residue, crop rotation and minimal disturbance no-till systems on soil quality as well as crop water use efficiency, yield and the economics of the various treatments. The four main treatments are based on different rotations including 1) continuous cereal (maximum carbon input, using different cereals), 2) diverse rotation (maximum diversity with cereal, legume and brassica), 3a) continuous wheat, 3b) continuous pasture (to boost soil carbon) and 4) a more common rotation with cereal, cereal and legume/fallow (maximum profit/district practice). To date the research has shown that: • Cover crops do not improve the yield of following crops, therefore are not viable for most of the wheatbelt. • Tines on the seeder did not result in significantly lower levels of crop residue compared with discs, as the residue could be managed by inter-row seeding. Therefore to achieve treatments with different levels of residue, plots were subsequently split into "all residue retained" and "windrow burnt". In addition, tillage and fallow treatments were introduced into one of the "control" rotations (tmt 4). The effects of these different treatments (windrow burn, fallow, and tillage) require more time to be confirmed. • It was also found that crop residue can reduce autumn and in-crop evaporation and therefore conserve soil water, but the amount of soil water and the yield benefits are yet to be confirmed. • Soil carbon appeared to fluctuate more with season than crop rotation or residue level, however, more seasons are required to confirm this. • Higher disease levels occurred in the continuous wheat, but, to date, this has only recently had a detrimental effect on yield. • The profitability of continuous wheat appears to be greater, relative to rotated wheat, in drier situations. However, yields appeared to be decreasing, especially in the last wetter season, and more seasons are required to confirm this effect and the sustainability of continuous wheat. It is expected that the next three years of research will generate new information on: • Yield and gross margins of 9-12 years of continuous wheat compared with more diverse rotations • Impact of rainfall/seasonal changes on profitability of continuous wheat • Changes in soil organic carbon under no-till with high levels of residue and different rotations • Seasonal impacts on soil organic carbon levels • Effectiveness of fallow in conserving soil water and nitrogen for following crops • Impact of summer rainfall on in-crop mineralisation and soil water storage in these different rotation and residue systems • Impact of residue level on crop growth, soil water storage and evaporation in autumn/early winter • Changes in weeds, insects and diseases in continuous wheat compared to a diverse rotation • Effect of windrow burning on changes in soil chemistry within and outside the windrow • Effect of windrow burning on weed populations

Preliminary study to improve long-fallow farming systems to maximise plant water use and farm profit, and reduce risk (DAV1709-004RTX)	A report summarising a preliminary study into the benefits and efficiency of long fallow in the southern region, consisting of: a. collection and analysis of fresh samples, and collation, statistical analysis and interpretation of data (soil moisture, yield, and soil nitrogen and carbon) from the SCRIME, LR1 and MC14 long term trials; b. a consolidated review of data from other long term trials conducted across the southern zone; c. results of preliminary model predictions of likely yield benefits of long fallow across a range of seasonal conditions;
Evaluating the potential of long fallowing to reduce whole-farm production costs whilst maintaining profit margin (UHS11009)	This study aimed to employ whole-farm economics to re-evaluate the role of long fallowing in the semi-arid Mallee region, and to determine whether a long fallow-wheat rotation could maintain profit margin and decrease income variability and value-at-risk when compared to continuous wheat and wheat-chickpea systems. Agricultural Production Systems sIMulator (APSIM) was used to simulate crop production on a 4000 ha property at Jil-Jil in North-western Victoria over a 20 year period (1997 -2016). Whole-farm economic analyses were used to compare rotations.