GRDC investments relevant to "deep dive" issues and strategic reviews of investment –
Low Rainfall Zone Southern RCSN – July 2019

Issue No. 36 "Better access to profit and production focused precision agriculture support would increase return on investment in the low rainfall zone"

GRDC investments addressing this issue

Assessing the economic value of precision agricultural tools for grain farming businesses in the Southern Region (9175511)	Precision Agriculture (PA) has considerable potential to increase the efficiency and profitability of grain production systems in the Southern Region, in particular to better target crop inputs to productive capacity and likely return on investment. The Society of Precision Agriculture Australia (SPAA) has been instrumental in promoting the development and adoption of PA technologies to Australian grain growers. The GRDC supported SPAA publication, PA in Practice II: Using precision agriculture technologies — a guide to getting the best results (2012), provides selected case studies, supporting trial results, technical articles and a list of available resources that demonstrate how PA is helping growers to maximise returns while controlling input costs. Despite generally high awareness of the potential benefits of PA technologies in cropping systems, adoption by growers in the Southern Region is generally low. A range of issues are believed to contribute to the relatively low adoption rates of PA including - • lack of clarity and local evidence regarding the financial benefits of available PA technologies; • the perception that PA increases the complexity of management, a deterrent for growers who prefer simple and streamlined operations; • a significant investment in time by growers and advisors is required to effectively utilise PA tools; • a limited number and geographical coverage of advisors with the skills, experience and confidence in PA exists. Typically, PA approaches involve considerable complexity and require interpretation of multiple and large spatial data sets including yield maps, NDVI measurements and different types of soil measurement and mapping (e.g. chemical analysis and EM38). Data platforms are frequently not compatible, which is a major issue for the integration, management, interpretation and use of information collected. Fortunately, many of the above challenges are being met by a range of experienced advisors and private organisations. For example, numerous specialist service providers have the capability and tools required to develop prescription maps for variable rate application of crop inputs and support the application and applied use of those maps on-farm. Also, a number of organisations now provide direct up-load of yield data from the harvester to the cloud, integration of data from a range of platforms and utilisation of NDVI data generated from satellite imagery or drones to produce production zone maps. With these barriers largely overcome, assisting growers to make economically informed decisions on the adoption and use of PA will be important. The GRDC project "The Integration of Technical Data and Profit Drivers for More Informed Decisions" examined the financial benefit associated with 20 case studies in PA adoption across Australia. Financial benefits varied considerably with the type of PA technology adopted, and the soil types and landscapes in which the technologies were employed. Hence, a "one size fits all" approach to the adoption of PA is not generally appropriate. Given the net impact on profitability is highly variable based on individual circumstance, it is essential that the application and adoption of a PA technology is carefully considered prior to any investment. It is suggested that building knowledge, skills and capacity would assist growers to objectively assess the operational, farming system and economic impact of the adoption of specific PA technologies to individual farm businesses. Access to robust and practical guidelines and decision support tools to assess the impact of PA technologies on the profitability of individual farm businesses is needed. The GRDC seeks to provide growers and advisers in the southern region with enhanced capacity and skills to

	assess the economic impact of the adoption of various precision agriculture (PA) technologies in order to make informed business decisions. This will be achieved by identifying key technologies and situations where PA has been proven to consistently improve the profitability of cropping systems; developing a simple decision matrix and related tools to support PA decision making; producing relevant high impact communications and extension activities to promote awareness and build the skills, knowledge and confidence to motivate growers and advisers to realise the profitability opportunities presented by the broader adoption of PA in the GRDC Southern region. By December 2019, growers and advisers will have enhanced knowledge, capacity, skills and confidence to make informed and objective economic decisions relating to the adoption of PA technologies aimed to increase the profitability of grain growers in the GRDC Southern Region.
Future Farm phase 2: Improving farmer confidence in targeted N management through automated sensing and decision support (9176493)	The Future Farm phase 2 project aims to re-examine and improve the way in which soil and crop sensors are used to inform decisions about input management and to provide a way of automating the process from data acquisition, through analysis, to the formulation and implementation of decision options. The initial focus is on improving the efficiency and profitability of applied nitrogen (N). It will focus on the adaptive generation of site-specific management models through increased and improved use of in-season field monitored data (soil, crop, climatic), historic on-farm data, external public and private data and automation of decision rules in software that may potentially be linked to real-time application equipment. In addition to strong communications and extension component, the project has three key outputs; 1) Developing improved calibrations that enable greater value to be extracted from proximal sensing tools for nitrogen sensors, 2) developing 'back-end' analytics software that could enable growers or advisors to integrate multiple data layers from on-farm (e.g. yield maps, soil tests) and off-farm sources (satellite imagery, weather forecasts) to predict the optimum N application, and 3) a proof-of-concept multi-sensor tool that integrated multiple streams of required sensor data to predict and apply the optimum N rate in real-time. The project is entering the second year of field trials in 2020 and has core 'farmer scale' research sites (i.e. 10 to 50 ha in size) in each of the GRDC regions in addition to 10-15 satellite sites. The core research site in SA is on Mark Branson's Tarlee property, and the core research site in VIC site is in Nhill. Further information about the project is available via: GroundCover article summarising the project GRDC media release covering part of the project GRDC Updates paper by Precision Ag researcher Brett Whelan In addition to this key investment, GRDC is currently negotiating project specifications for 4 new investments in precision agriculture related to early disease detection, rapid quantification of frost damage, rapid and detailed spatial measurements of PAW and remote monitoring of crop phenology. Further information about these 'Enabling Analytics for Grain Crop Monitoring' tenders can be found here.
Application of Precision Ag Tools to a Wheat Breeding Program (GRS11009)	High-throughput phenotyping has the potential to provide great advances to the plant breeding industry, with phenotyping sensors having been proven useful in controlled environments and in small scale research. However, their implementation has yet to be realised at a large scale. This project aims to; 1) implement high-throughput phenotyping in a large scale wheat breeding programme, 2) investigate data extraction methods and statistical analysis methods of the phenotypic data collected, and 3) ultimately use this data to improve genetic gain within the breeding programme. This will be combined with environmental characterisation data to better understand variation within, and between field sites. Phenotyping sensors (primarily DSLR cameras and LIDAR sensors) will be used to characterise field trials across multiple sites in the 2016 and 2017 growing seasons, with this data being compared to manually recorded measurements. Methods for data extraction from phenotyping sensors will be developed, as well as statistical analysis methods for using this data within plant breeding programmes. Australian Grain Technologies is well situated to partner with the University of Adelaide and the PhD candidate on this project having the appropriate resources, as well as a highly capable PhD student who has already spent a year working on the project.
A platform to interpret soil attributes to support profitable farming systems (US00087)	This innovation will deliver platforms for fine scale mapping of soil attributes to provide reliable real-time information to growers to support their decision making processes. Profitable farming systems depend on high quality data, including soil data, to manage annual agronomic decisions affecting crop performance. This good soil management will also secure soil production potential into the future, reducing long term risk. Developing this system requires soil and its related data to be measured at a finer scale than is currently feasible for farming systems relying on data derived from traditional soil laboratory techniques. The reduced cost of generating this data will increase the growers' ability to assess variability in the field and support

	precision agriculture approaches to reach their full potential. While a number of sensors have been developed to measure soil properties quickly, cheaply and in situ, the current investigations have focused on a single or small number of properties, or developed calibrations that are only suitable for a given region or soil type. There has also been no explicit linkage to any interpretation of the agronomic impacts of the measured properties. This research will fill these gaps by developing calibrations for proximal soil sensor measurements and connecting sensor derived properties with the wealth of information held in pedotransfer functions through the use of a spectral inference system. Much of this work will be automated and will culminate in the production of a standardised report presenting key soil attributes in an easily interpretable way.
GRS - Optimising crop predicted and produced yield through an intuitive and cost effective decision support tool (**UOS1807-001RSX)**	Precision agriculture and the use of Site-Specific Crop Management (SSCM) can deliver higher profitability with a lower environmental cost by tailoring management actions to suit the spatially varying demands of crops. Remote sensing allows us to identify winter wheat (Triticum aestivum) and sorghum (Sorghum bicolor) crop demands over a larger area in a shorter time than traditional methods, and, when coupled with sophisticated statistical and modelling techniques, can match or exceed the robustness of their estimates. Remote sensing can detect a wide range of biophysically significant variables, such as photosynthetic efficiency, soil moisture content as well as leaf concentrations of nitrogen. Using these variables with climatic and topographical conditions can drive estimates of grain yield potential, as well as prescription maps of how much nitrogen to apply where to achieve them.
Precision Ag EXPOS (SPA1902-001AWX)	Precision agriculture conference support
GRS (Andrew Longmire)- Hyperspectral remote sensing of wheat crops for rapid assessment of effective nutrient status and improved crop growth model performance (**UOM1903-001RSX)**	The overarching objectives of this PhD project are to apply hyperspectral image collection and processing to enable more accurate, more reliable and faster decision-making in the context of precision agriculture and to improve crop growth models by assimilation of remote sensing (RS) outputs. The project takes a multidisciplinary approach by combining state-of-the-science techniques from remote sensing, model inversion and statistics with traditional agronomic and plant science experimental approaches. These can potentially be applied to problems of global importance and real-world relevance to grain growers. Across the Australian grains industry, crop use efficiency of applied N is around 50%. The other half escapes from leaky agroecosystems, representing a very significant cost to farmers, who pay up front for fertiliser and therefore assume significant financial risk. Modern techniques in RS and image processing have the potential to improve targeting of fertiliser to crop needs, for example by assessing the actual effect of N status on plant physiological performance. Solar-induced fluorescence can be directly observed and is considered a direct proxy for electron transfer rate and therefore photosynthesis, as well as being closely linked to Vcmax. Hence it is now possible to quantify net assimilation by analysis of images captured by airborne sensors mounted on either piloted or unpiloted aircraft. Moreover, other indicators of plant function, including chlorophyll concentrations, leaf N content and canopy structure (e.g. LAI) can be derived by inverting leaf and canopy physical models, and the high spectral resolution of hyperspectral RS can also be used to derive a wide range of finely-tuned reflectance indices. These techniques are a vast advance on crop RS methods currently practiced in Australia, which rely on simple reflectance indices incapable of delivering insight into plant and crop function beyond assessments of greenness. This project is aimed at the following objectives: 1. Improved matching of nitrogen fertiliser to crop needs using RS hyperspectral imagery and processing algorithms to diagnose and map spatial variability in crop plant performance, specifically photosynthetic rate, by direct observation of solar-induced chlorophyll fluorescence. Application: In the context of precision agriculture utilising drone-mounted and aircraft-based spectral sensing equipment, this will improve farmers' capacity to target their tactical agronomy more accurately by assessing both temporal and spatial variations in crop performance. 2. Improve crop growth models and decision support tools by assimilating RS-derived knowledge of plant / crop performance, including leaf area index, chlorophyll concentration, photosynthetic rate and other aspects of leaf and crop canopy structure. Application: In the context of crop growth models currently in use in Australia, particularly APSIM / YieldProphet™, this would aim to improve the models' skill in predicting yield and grain protein.
ACT00004 - Application of CTF in the low rainfall zone°	Adoption of Controlled Traffic Farming (CTF) in the low rainfall zone (LRZ) of the Southern Region is very low (eg SA/Vic Mallee, 4%) compared to other zones in the Region (eg Vic HR, 26%) (GRDC 2012 Farm Practices Survey). This is believed to reflect scepticism about its benefits in many LRZ environments when weighed up against the cost of adopting the practice. The project 'Application of controlled traffic in the low rainfall

	zone' will evaluate whether or not this scepticism is justified. It will use a balanced combination of research and development (R&D) to answer growers' questions about CTF and provide the information they need to make informed decisions about whether to invest in adopting the system on their farms. To help LRZ growers answer the questions and uncertainties they face when thinking about CTF adoption, the project will conduct research on four sites (R sites) across Southern Australia at: ➢ Loxton ➢ Swan Hill ➢ Lake Cargelligo (NSW) and ➢ Minnipa. At these sites, information will be gathered on soil properties and crop growth under a range of existing compaction situations to enable comparison of crop productivity between current guidance systems and full CTF. APSIM and yield Prophet modelling will be used to help evaluate crop response to controlled traffic over a wider range of seasonal conditions. The research data from these sites will be supported by information from smaller development sites and will more broadly investigate: i) how well soil compaction effects can be reduced by self-repair or amelioration practices, ii) the power and energy benefits from CTF and iii) the system (timeliness and uniformity) benefits of CTF. The research activity will provide valuable information to help answer the important questions being asked about the relationship of CTF to grain productivity in the LRZ, especially on the characteristically light soils of the region where there is currently little information on soil compaction or its effects, or on the effectiveness of CTF systems.

Issue No. 42 "Crown Rot is increasing with changed farming practices leaving stubble crowns intact and not susceptible to breakdown"

GRDC investments addressing this issue

Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in Victoria (DAV00129)	This project operates under three broad objectives, i) generation of knowledge, tools and technology which improve disease management and incorporation of research results from research trials and demonstrations into disease management packages, ii) systematic surveillance, monitoring and disease diagnostics, and iii) services to growers and agronomists through provision of extension information and disease identification and IDM training relevant to the local environment and farming systems. Research focuses on integrated disease management of yellow spot in wheat, scald and net form of net blotch in barley, viruses in cereals and pulse crops and fungal diseases of pulses in the Southern Region.
Yield loss response curves for host resistance to leaf, crown and root diseases in wheat and barley' (DAW00245)	This project has been designed to develop more accurate yield loss information for the major diseases of wheat and barley, including crown rot, yellow spot, septoria nodorum blotch, septoria tritici blotch, net blotch, scald, barley leaf rust and powdery mildew and nematodes. The five-year project, from 2014/15 to 2018/19, will generate yield responses to regional priority pathogens and nematodes for a range of varietal resistances and disease pressures from negligible to severe. This is being be done by conducting field trials across a range of cropping regions where the diseases occur. The project is developing information to support crop agronomic decision-making, considering crop sequence, varietal selection, stubble management, seasonal climate, for disease risk considerations. By gaining improved understanding of the actual impacts of disease, more growers and advisers will make improved agri-chemical and plant variety decisions, which will result in improved profitability and sustainability.
Centre for Crop and Disease Management (CUR00023)	CCDM Program 1 - Project A - Early detection and management strategies for fungal diseases CCDM Program 1 - Project B - Best management practices for fungal disease control CCDM Program 1 - Project C - Economics of disease management and capacity development. CCDM Program 2 - Extension and engagement CCDM Program 3 - Septoria nodorum blotch biology CCDM Program 4 - Tan (yellow) spot CCDM Program 5 - Net form of Net Blotch Functional Genomics CCDM Program 6 - Sclerotinia Stem Rot of Canola and lupins CCDM Program 6 - Ascochyta blight of pulses

	CCDM Program 8 - Durable Resistance to Powdery Mildew CCDM Program 9 – Fungicide resistance
National pathogen management modelling and delivery of decision-support (DAW00228)	Improving crop yield in Australian farming systems is hindered by a number of factors; crop disease is one of them. Recent reports commissioned by GRDC indicate that the annualised costs of diseases of cereals, and oilseeds and pulses is over $1.2 billion and $210 million, respectively. Managing diseases at the right time with the right control techniques can and will substantially reduce the costs of diseases and thereby increase farm income. However, such management needs to be economically viable. This project aims to provide the grains industry with tools and processed information in order to aid decisions on economically feasible crop disease management.
National improved molecular diagnostics for disease management. (DAS00137)	This project will reduce the costs and losses through improving grower management of crop soilborne diseases. This will be achieved by industry increasing cost effective adoption of fungicide resistance management plans to 50% and increasing cultural management strategies as a key control strategy to 40% of growers surveyed by GRDC. This will be achieved through the delivery of the following objectives: 1. New knowledge, tools and technologies that provide an effective balance of genetic, cultural and chemical options for control and that support the integrated management of crop disease and impacts on yield, quality and crop returns. 2. Manage and prioritise emerging pathogen risk by improving knowledge of epidemiology for current and emerging diseases through systematic survey and modelling. 3. An Increased focus on emerging diseases affecting grain quality and production, and improved molecular diagnostic field monitoring, early warning tools and models which will reduce costs and losses for growers. 4. Increased grower and advisor use of an integrated approach using resistant varieties, cultural management and fungicide use options to support crop planning and in-a-op disease minimisation. 5. Advisors will have targeted plant disease training so that growers can have access to independent information to manage crop disease appropriate to their geographic circumstances and crop rotations.
Regional Agronomy SA - Improving disease management through improved agronomic practices (DAS00167-BA)	This project forms part of the broader SARDI and GRDC bilateral regional agronomy research effort and will employ a research agronomist based at the Primary Industries and Regions South Australia (SA) Port Lincoln regional office in the Eyre Peninsula region of SA. The agronomist will work closely with a range of industry stakeholders in addressing regional issues and opportunities. A key output of the research project will be the development of sustainable management strategies that enable growers to sustainably control a range of crop diseases. The research agronomist will also work closely with the rest of the bilateral team to ensure that the research findings from their work are communicated to industry. A further key output of this project is to develop the skills and capabilities of the Research Agronomist (LEP), to enable them to be of significant benefit to SARDI, GRDC collaborating research agencies, the grains industry sector, agribusiness, chemical companies, farming system groups and growers in the field of agronomic research. The Research Agronomist (LEP) will work with the rest of the SARDI/GRDC bilateral project team, GRDC, related groups within SARDI and other agencies, to develop their skills in research, agronomy, farming systems and especially in field pathology related issues. This will improve the capacity of the R&D sector of the industry to address and overcome critical limitations and research gaps in the profitability and sustainability of southern Australian farming systems. Guided by a literature review, this project will identify at least three field crop diseases where improvements in management are possible and then instigate a range of field experiments and paddock surveys to produce a range of integrated disease management strategies aimed at improving the efficacy of current best management practice. An example of how an improved knowledge of agronomy and the need to develop new strategies in line with changes in farming practice may come about from the high incidence of aerial blackleg observed in recent years. This is thought to have arisen as a result of a trend towards earlier sowing of canola, which has led to the canola plant being more physically developed by the time blackleg spores are released in early winter, hence the disease attacks a different part of the plant to where it has traditionally. Possible management strategies could involve investigating differing varietal development characteristics that lead to the plant flowering in a preferred window that reduces the risk to the more difficult to control aerial blackleg infection.

Durum Crown Rot benchmarking for improved grower access to durum varieties with greater Crown Rot resistance (**USQ1904-002RTX)**	Durum Crown Rot benchmarking for improved grower access to durum varieties with greater Crown Rot resistance - Summary Crown rot, caused by *Fusarium pseudograminearum*, is a major disease constraint on the further development of the durum industry in Australia as all the current durum varieties grown are susceptible to the disease. Given an estimated yield loss to crown rot of around 50-60% under conditions favourable to the disease, producers have placed a high priority on the development of cultivars with improved resistance to this disease. In a recently completed GRDC-funded pre-breeding program (USQ00013) more than ten different sources of crown rot resistance was crossed with current durum varieties to introduce crown rot resistance into durum. Progeny of these crosses underwent multiple rounds of screening for crown rot resistance and re-selection. In the new benchmarking project advanced lines with improved crown rot resistance from different sources produced under project USQ00013 will be further assessed. Tolerance trials will be conducted at six different sites across Australia. Trials will include at least 50 lines from USQ00013 and 50 lines provided by Dr Amer Dababat from CYMMIT-Turkey together with wheat and durum standards. Yields from inoculated and un-inoculated plots will be recorded and plots assessed for crown rot disease. The best durum lines will be provided to durum breeders for further development into new durum varieties with improved crown rot resistance. Durum varieties with improved crown rot resistance will result in higher yields, increased income stability for the producer and the potential for the durum industry to develop the export market.
USQ00013 - Managing crop diseases - Improving crown rot resistance in durum (COMPLETED MAR 2019)	Australia is an important producer of durum or pasta wheat and currently grows 300,000 to 500,000 tonnes annually. Annual yield losses in all wheats due to crown rot (CR) disease have been estimated to be around $79 million, with potential losses of up to $434 million in a single season. Current durum wheats are very susceptible to CR disease and to date durum lines with high resistance to this disease have not been identified. CR disease severity is exacerbated under water stress conditions, particularly when this occurs late in the growing season. With Australian grain-growing regions forecast to become hotter and drier due to global warming, yield losses due to CR disease are expected to increase. Development of varieties with improved CR resistance is pivotal to the expansion of the Australian durum industry. Bread and wild tetraploid wheats carrying a level of resistance or tolerance to crown rot disease have been identified. This project aims to transfer improved reaction to crown rot from these sources into high-yielding commercial durum varieties, thus increasing returns to rural producers. Genetic markers that indicate the presence of genes that resist growth of or provide tolerance to this fungal disease will be used as flags to detect the presence of resistance genes in populations of durum plants derived from crosses between resistant lines and elite durum varieties. Once we have demonstrated that lines which inherit these markers reliably show increased resistance, these markers can be used by durum breeders to assist in the breeding and efficient selection of improved varieties.
US00075 - Integrated Genetic Solutions to Crown Rot in Wheat	Demand for improved resistance and tolerance to crown rot in wheat led to the establishment of Phase one of the Crown Rot Initiative (CRI), with much momentum being generated in the development of crown rot resistant and tolerant material. This project seeks to capture the momentum by continuing to pyramid partial resistance and tolerance sources from phase one into adapted backgrounds and make these sources available to Australian breeding entities. This pyramiding will be informed by an association analysis which will ensure that multiple unique sources of resistance are combined. Several challenges to the delivery and adoption of these sources was identified in the first CRI. One of these challenges was difficulties in current phenotyping methods to reliably and efficiently be used in both pre-breeding and commercial applications. To overcome these difficulties, this project will aim to improve current phenotyping strategies, by delivering reliable, repeatable, and robust phenotyping methods to breeders and pre-breeders. The achievement of such outcomes will not only allow more accurate identification and selection of resistance and tolerance traits in pre-breeding activities but increases the likelihood of these traits being adopted and selected through commercial breeding programs and eventually being released to Australian growers. Much focus is also directed to improving current molecular strategies for identifying genetic regions for crown rot resistance and tolerance. This includes confirming the validity of Quantitative Trait Loci (QTL) detected in seedling-based assays in field tests, and determining their effect in multiple genetic

	backgrounds. This project will also aim to refine the current loosely linked flanking markers for four known resistance QTLs, allowing them to be more efficiently deployed in commercial breeding applications.
UQ00049 - Rapid introgression of crown rot resistance into hexaploid wheat	Crown rot (CR), caused predominantly by *Fusarium pseudograminearum* teleomorph Gibberella coronicola), is a major soil-borne disease of wheat and barley. The disease is widespread and causes significant losses in yield and quality. Inclusion of effective genetic resistance (or tolerance) to CR in cereals has significant potential to reduce these losses. This project seeks to rapidly move multiple genes conveying resistance/tolerance to CR into adapted, high-yielding genetic backgrounds of bread wheat. This new genetic material will be used by breeding companies to develop new wheat varieties that will be able to maintain yield in the presence of the disease. This project forms part of the GRDC-funded Crown Rot Initiative (CRI). In this project a combination of technologies will be applied to rapidly move genes (from multiple sources) into bread wheat and so produce new lines of with an improved reaction (i.e. effective tolerance or resistance) to the presence of CR under field conditions. These technologies include: • speed breeding; to accelerate plant development and reduce plant generations to 12 weeks • high-throughput seedling and nursery screens to allow large populations to be evaluated for CR reaction • use of advanced molecular genetics tools to identify gene segments that contribute to CR resistance and/or tolerance • Three cycles of crossing, screening and evaluation are planned. The project is closely linked to other GRDC-funded projects that form the CRI. Information and genetic material will be shared between projects in the CRI that will tackle the problem of crown rot in different ways to maximise the likelihood of successful outcomes for Australian wheat growers. The project led by Dr Mark Dieters at the University of Queensland will focus on the development of CR resistant/tolerant material that is adapted to the northern wheat-growing regions of Queensland and NSW but also aims to develop material adapted to southern and western wheat-growing regions of Australia. High-yielding, adapted varieties will be inter-crossed with the best available sources of known crown rot resistance. Donors likely to carry different genes for resistance to CR have been selected. We aim to target-stack multiple sources of genetic resistance to CR and rapidly develop lines that have at least a 90% similarity to current commercial varieties and combine high levels of resistance/tolerance to CR with high yield potential. Repeated cycles of inter-crossing and selection will be used to break-down unfavourable genes linked to the introduced CR genes, reduce the size of the DNA segments introduced with the desirable CR genes and combine the multiple resistance genes. Speed breeding in the glasshouse, combined with evaluation under field conditions in the winter and summer seed increase in WA will permit multiple plant generations each year, allowing rapid progress. Advanced genetic tools will be used to identify DNA regions that carry the CR genes and select lines with the most desirable genetic make-up. We expect to deliver effective tolerance to CR within an adapted genetic package for the major wheat-growing regions of Australia. This new material will be genetically very similar to successful varieties that are currently grown in these regions, but with added tolerance to crown rot. Material developed will be made available to the Australian wheat breeding programs for further evaluation as potential new varieties and breeding lines.

Southern Pulse Agronomy, Southern Pulse Validation and Southern Pulse Extension investments

GRDC investments -

Understanding the implications of new traits on adaptation, crop physiology and management of pulses in the southern region (DAV00151)	This project is investigating traits for modern farming systems - Strategic genotype x management research will be conducted that provides information on understanding and maximising the benefits of new traits/genes recognised in the breeding program through improved crop management: a. Herbicide tolerance and weed ecology (notably Group B and emerging Group C chemistry) b. Disease management (i.e. Field pea Blackspot) c. Canopy management (Biomass and plant architecture) d. Harvest quality (adverse weather prior to harvest and effects upon grain quality) Variety specific agronomy packages are a focus of this investment that predominately is focussed upon traditional pulse growing region of the GRDC Southern region – Hence limited specific trials for LRZ (these

areas are considered in the variation to this project in the Southern Pulse Validation component) – LRZ trials as part of the existing Southern Pulse Agronomy project were located mostly at Ouyen, Minnipa and Birchip

2016 TRIALS	
Crop	**Focus**
Faba Bean	Plant Density - 2 varieties x 5 sowing rates
Chickpea	Disease Management - 2 fungicide treatments x 19 varieties
Chickpea	Crop Topping - 10 varieties incl nil treatment
Field Pea	Disease Management - 4 varieties x 4 fungicide treatments
Field Pea	Understanding growth traits of existing varieties
Field Pea	Harvest Quality - 4 timings x 8 varieties
Lentil	Sowing Time - 2 TOS x 5 rates x 12 varieties
Lupin	Plant Density - 3 seeding depths x 4 sowing rates
Lupin	Investigation traits of new varieties for LRZ suitability
Field Pea	Disease Management - 8 fungicide treatments
Chickpea	Variety trials - 5 varieties
Faba Bean	Variety trials - 6 varieties
Field Pea	Variety trials - 7 varieties
Lentil	Variety trials - 7 varieties

2017 TRIALS	
Crop	**Focus**
Lentils	Sowing Time - 2 dates x 20 early type varieties
Lentils	Herbicide Tolerance - 6 Group B treatments x 4 varieties
Field Peas	Sowing Time - 2 TOS x 12 Early maturing Varieties
Field Peas	Harvest Quality - 8 varieties x 4 4 harvest timings + crop topping
Chickpeas	Disease Management - 17 varieties x 4 fungicide treatments
Chickpeas	Sowing Time - 2 TOS x 12 Early maturing type varieties
Faba Bean	Traits - early maturing for drought selection
Lentils	Sowing Time - 2 TOS x 20 Varieties (early maturing)
Field Peas	Sowing Time - 2 TOS x 2 Varieties x 6 fungicide strategies
Faba Bean	Herbicide Tolerance - 9 Group B treatments x 2 varieties
Lupin	Investigation traits of new varieties for LRZ suitability

2018 Trials	
CROP	**Focus**
Lentils	Investigation traits of new varieties for LRZ suitability
Lentils	2 Varieties x 25 Group C treatments +/- Brodal
Chickpeas	15 varieties x 4 fungicide treatments
Chickpeas	2 varieties x 10 fungicide treatments (incl. seed treatments)
Faba Bean	Traits - LRZ early maturing for drought selection
Lentils	Sowing Time - 4 TOS (+/- Irrigation @ TOS 1) x 2 soil types x 2 varieties
Lentils	Herbicide Tolerance - 2 x Metribuzin rates x 2 application timings x 2 soil types x 2 varieties
Lentils	Nutrients - 1 1treatments (including Omission) x 2 soil types x 1 variety
Chickpeas	Sowing Time - 4 TOS (+/- Irrigation @ TOS 1) x 8 varieties
Chickpeas	Nutrients - 1 1treatments (including Omission) x 2 soil types x 1 variety
Field Peas	Disease Management - 5 fungicides x 2 application timings

Improving the profitability of pulse production through local validation of research outcomes in the Southern Region (DAV00150)	A targeted validation trial program (2018 and 2019 seasons) 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 (*i.e. Non-traditional pulse growing regions*). This variation is an expansion of the existing Southern Pulse Agronomy project and will deliver greater knowledge of the pulse phenotypes suited to each agro-ecological zone and management practices to optimise their production and profitability. These data and results will further increase confidence in pulse production and will inform optimum agronomic practices for specific pulse phenotypes through evaluation of their applicability, profitability and risk in local LRZ environments.

2018 TRIALS	
Crop	**Focus**
Chickpea	Sowing Time - 2 sow dates x 3 varieties x 3 plant densities
Chickpea	Sowing Time - 2 sow dates x 6 varieties
Chickpea	Inoculants - 2 varieties x 5 inoculants
Chickpea	Variety trials - 6 varieties
Chickpea	Variety trials - 6 varieties
Chickpeas	Inoculants - 9 treatments
Chickpeas	nutrients - 5 treatments x dune / swale differences
Chickpeas	Disease Management - 6 Fungicide strategies x 2 varieties
Chickpeas	Inoculants - 11 inoculant treatments
Field Peas	Inoculants - 9 treatments
Field Peas	nutrients - 5 treatments x dune / swale differences
Field Peas	variety testing - 12 lines Focussed on low rainfall
Field Peas	Disease Management - 10 Fungicide strategies (seed treatments and fungicides)
Lentil	Nutrient treatments - 5 treatments x dune / swale differences
Lentil	Variety trials - 6 varieties across dune / swale soils
Lentil	Sowing Time - 2 sow dates x 3 varieties x 3 plant densities
Lentil	Sowing Time -2 sow dates x 6 varieties
Lentil	Herbicides - 1 variety x 24 treatments
Lentil	Variety trials - 6 varieties
Lentil	Nutrients - 15 strategies x 1 variety
Lentils	Herbicide Timing - 3 Varieties x 3 timings x 2 depths
Lentils	Variety x soil effects - 9 varieties x 2 soil types (Sand v loam)
Lentils	Inoculants - 9 treatments
Lentils	variety testing - 12 lines Focussed on low rainfall
Lentils	Disease Management - 4 Fungicide strategies x 2 varieties
Lupins	Herbicide Time - 3 Varieties x 3 timings x 2 depths
Multi (x3 crops)	Herbicide effects - 5 Herbicides x 4 rates x 2 timing x 2 rates x 3 crops

Building capacity, skills and knowledge for the pulse industry in the Southern Region: Supporting expansion of high value pulses into new areas and ensuring sustained profitability of all key pulse crops in existing areas. (9175825)

This extension project is targeted as directly building the skills, knowledge and confidence of growers in the production of high value pulse crops, focusing upon lentil and chickpea, and to hasten the successful expansion in area planted to these crops in the Southern Region in non-traditional or expanding pulse production areas.

The project also is focused on capacity building within the advisory sector to build future industry leaders and provide agronomic support to growers. This investment involves delivery of discussion groups, training, workshops and communication materials to realise long-term farming system and financial benefits to build capacity, skills and knowledge for the pulse industry in the Southern Region.

12 pulse check groups have been established that meet 4 times annually to discuss timely / topical pulse production issues. Locations of pulse check groups are:

- Cummins
- Lock
- Cleve
- Kimba
- Napperby
- Coonalpyn
- Loxton
- Mannum
- Werrimull
- Pinnaroo
- Pyramid Hill
- Dookie

The project has also run several open pulse workshops and conducted reseller (agribusiness) activities to ensure involvement. Trials of the Southern Pulse Validation investment are heavily utilised in extension

	messaging.
Validation of recent research upon break crop options in climate, soil type, and biotic stress situations (DAS00162-A)	The long-term aim of this project is to improve production and profit of low rainfall farming systems through the adoption of break crop management packages specifically developed for low rainfall farming systems. This project builds on GRDC funded projects: ➢ DAS00119 (Profitable crop sequencing in the low rainfall areas of South Eastern Australia) ➢ DAV00113 / DAV00150 (Southern Pulse Agronomy) ➢ CSP00187 (Optimising Canola profitability), and ➢ SAGIT funded project MSF115 (Adopting profitable crop sequences in the SA Mallee). Field trials are established in the major LRZ cropping regions: ➢ Upper Eyre Peninsula, SA ➢ Upper North, SA ➢ Murray Mallee, SA and ➢ Northern Mallee, Victoria Soil characteristics, soil moisture, grain yield, and biomass yield were measured at each site. Trials were established to address the two key project aims: 1. Information about which break crop is likely to do best for each major climate x soil type combination including biomass yield measures to identify potential use as a hay, dual purpose, forage or manure crop. 2. Identify low risk break crop management strategies for more profitable break crops. a. Canola nitrogen management b. Lentil pre-emergent herbicide application timing c. Chickpea ascochyta blight fungicide timing d. Field pea blackspot fungicide management e. Lentil sowing density f. Lentil stubble management g. Field pea, lentil, chickpea and lupin inoculant rate
Increasing symbiotic nitrogen fixation for the benefit of following crops (9176601)	This extension and communication investment adds value to previous and current GRDC projects improving N fixation of winter pulse crops and promoting their wider adaptation and adoption. The three year investment commenced in in 2018, working with local influencers to promote best management inoculation and pulse management practices, and raise awareness and knowledge around pulse nodulation and N fixation, and the impact of soil acidity, especially subsoil acidity.
Increasing the effectiveness of nitrogen fixation in pulse crops through improved rhizobia strains, inoculation and crop management practices (9176500)	Recent expansion of the pulse industry is seeing crops increasingly grown in new and marginal environments that are responsive to rhizobial inoculation. In these situations, the viability of the pulse crop is strongly dependant on the availability of competent inoculant strains of rhizobia and best practice application of those rhizobia. This project will improve the viability and profitability of high value pulses (bean, lentil and chickpea) through the provision of improved inoculant strains, the assessment of inoculant delivery technologies under hostile establishment conditions and improved understanding of pesticide impacts on the symbiosis. It will demonstrate where inoculation is of value and identify opportunities for future symbiotic improvement. Specifically, the program will: • Complete the evaluation and commercialisation of a new acid tolerant strain of rhizobia for bean and lentil. • Isolate, test and short list improved rhizobia for chickpea. • Provide an objective assessment of inoculant technologies across a range of marginal environments and sowing conditions. • Quantify the impact and develop strategies that minimise the impact of crop protection and herbicide applications on pulse N fixation. Promising strains of acid tolerant rhizobia for faba bean and lentil have been identified in previous GRDC supported research. The next phase of this work will focus on commercialising one of the strains and understanding the pH boundaries where it reliably delivers benefits. The ability of the new rhizobia to

	survive in soils outside of the host plant, will also be tested, which is an important to understanding future inoculation requirements. Similar rhizobia strain improvement work will be initiated for chickpea. New formulations and methods of inoculant application have been developed by industry to improve the options that growers have to inoculate their crops. However, there is a lack of current objective information on how the inoculants perform especially when sown into hostile soils. This project will assess the merit of different inoculant formulations and whether they provide advantages under challenging conditions, including where they are applied under dry sowing conditions. The effectiveness of inoculation can also be reduced through mixing with additives such as herbicides, fungicides, insecticides and fertilisers. The impacts, particularly on N fixation, are easily overlooked in the field. The extent to which crop protection chemicals are impacting on N fixation will be measured and growers and industry informed about which pesticides are most damaging and avoided where possible. The work will investigate the extent to which herbicide tolerant pulse varieties overcome the detrimental impacts of some herbicides on N-fixation. The project will be delivered by applied N-fixation researchers from the South Australian Research and Development Institute and University of Adelaide, collaborating with southern pulse agronomy and farming system groups in SA and Victoria. The program will have a strong field focus. To encourage practice change, the benefits will be demonstrated in validation trials across southern region in collaboration with key influencers of the pulse industry.
Managing legume and fertiliser nitrogen in the southern region (UA00165) COMPLETE 2018	Grain growers in the southern region have a high level of uncertainty about the amount of nitrogen (N) supply required for cereal crops and the value of legume N in their cropping systems, including the amount of N contributed by legumes and when that N is available to the following crop. A significant amount of research has been done in quantifying amounts of N fixed by different legume crop and pasture species, but this information is only a small part of what is required by growers to make rational fertiliser decisions for following crops, and will depend on the frequency of legumes in rotation. What growers need to know is what proportion of the legume N is made available to the following crop or crops and the timing of the N availability and how this compares with fertiliser and mineral N, in order that they can supply appropriate N to cereal and canola crops in the southern region. The project will assist advisors and growers through improved knowledge and tools to assist the prediction of N supply from legume and fertiliser in the southern region. In summary, this two year project will: • Seek advisor and grower input on issues with current N fertiliser decisions, through facilitated workshops, • Produce a preliminary report on the current knowledge of N cycling and N management in commercial grain production systems of the southern grains region. • Evaluate and develop a support tool or tools, fact sheets and, for the southern region to assist in N decision-making by growers and advisors; • Develop a comprehensive user-friendly manual to be used by advisors and growers in the southern region to inform decisions on fertiliser N and soil N management in grain cropping • Capture advisor and grower feedback on the tool/s and manual through facilitated workshops.