GRDC INVESTMENTS ADDRESSING A SELECTION OF ISSUES – LOW RAINFALL ZONE RCSN – December 2017

Issue No. 1 - Improved pulse varieties to improve profitability of farming systems in the low rainfall zone

The development of high value pulse varieties, especially lentils and chickpeas, which are better adapted to low rainfall environments and farming systems would increase the area sown to pulse crops and thereby increase long term profitability. Improved varieties of pulses for situations where high value pulses are not suited would also increase in the area sown to pulses and thereby enduring profitability of growers in the low rainfall zone. Identified issues and traits of improved varieties include, lupins tolerant of free lime and high residue field peas which provide protection of soils from wind erosion.

GRDC investments addressing this issue

Pulse Breeding Australia – Lentil Breeding Program (DAV00119)	Project outputs are: 1. One broadly adapted medium to large-seeded IMI tolerant red lentil variety with the following characteristics: - Yield higher than PBA Hurricane XT - Ascochyta resistance rating of R - Shattering, pod drop and lodging resistance of at least MR - Flowering and maturity equivalent to PBA Hurricane XT 2. At least one other IMI tolerant variety with the following characteristics: - Moderate salt tolerance (at least equivalent to Nipper) - Early maturity equivalent to PBA Blitz - Yield higher than PBA Hurricane XT - Ascochyta resistance rating of at least MR - Shattering, pod drop and lodging resistance of at least MR 3. A conventional red lentil variety with the following characteristics: - Tolerance to boron equivalent or superior to best PBA lentil varieties - Yield superior to PBA Bolt - Moderate salt tolerance (at least equivalent to Nipper) - Ascochyta resistance rating of at least MR - BGM resistance superior to PBA Bolt - Shattering, pod drop and lodging resistance of at least MR

	- Maturity equivalent to PBA Bolt 4. Lines with novel herbicide tolerance from project (DAS00107) evaluated in the field.
Pulse Breeding Australia – Chickpea Breeding (DAN00212)	Project outputs will be new varieties with increased yield potential and improved seed quality. The project will concentrate on a restricted set of breeding objectives: resistance to disease (AB, Phytophthora root rot (PRR); appropriate phenology (allied to chilling tolerance); salt tolerance; improved harvestability; and improved seed quality. The mix of adaptive features incorporated into new varieties will reflect the regional importance of the key production constraints. Breeding target traits for medium rainfall zones (Wimmera (Vic), south eastern (NSW), Yorke Peninsula, Mid-North, Lower Eyre Peninsula) are: **Desi traits:** • maintain AB resistance equivalent to PBA Slasher • improved adaptation and farming system fit through phenology, particularly chilling tolerance and earlier maturity • improved harvestability through plant type, increased pod height and improved lodging resistance • improved seed colour and size (equivalent to PBA HatTrick) • improved salinity tolerance as identified in controlled environment screening • improved registered herbicide tolerance and/or novel herbicide tolerance if identified in the herbicide tolerance project (DAS00107). **Kabuli traits:** • increased AB resistance with 9 mm seed size • increased adaptation through phenology, particularly chilling tolerance • improved salinity tolerance as identified in controlled environment screening • improved registered herbicide tolerance
Understanding the implications of new traits on adaptation, crop physiology and management of pulses in the southern region (DAV00151)	1. New 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 - Understanding the agronomic importance and viability of traits linked with weed management and herbicide tolerance in lentil and faba bean (metribuzin and Group B tolerance) and chickpea (potentially Group B and Group I). Implications for weed management and ecology will also be considered, including early maturing varieties for crop topping. b. Disease management – In field pea, blackspot continues to be a major limitation to production. Recent work in SA by the SPA and in France by INRA suggest there are opportunities to minimise the risk of blackspot by combining novel fungicide applications, with improvements in genetic resistance enhanced by plant morphological and architectural differences. In faba bean and chickpea, resistance to ascochyta blight has recently broken down and implications for management packages need to be elucidated. c. Canopy management (biomass and architecture) – In lentils and faba beans improvements in vigour, architecture and biomass development combined with improved disease resistance, may require reduction in seeding rates, particularly when combined with early sowing dates to secure yields in dry years. There are also opportunities to better manage bulky canopies and maximise pod set through a combination of crop management and genetic practices including the use of PGR's. d. Harvest quality – Little is understood about the impact of adverse weather events on mature crops, yet major quality and industry issues have arisen when they have occurred in the past. Genetic and agronomic differences have been reported as being important in reducing quality losses. Opportunistic research through trials assessing delayed harvest and weather events on a range of genotypes under the same conditions will add to this knowledge both for producers and breeders. 2. Variety specific agronomy packages (VSAP) - Targeted agronomic research will produce data for new pulse varieties which will be synthesised into management packages for the southern Australian cropping regions in collaboration with PBA or other pulse breeding organisations. This will deliver maximum benefits of new varieties to growers immediately after they are released. The pulse industry views the delivery of VSAP's and the matching of genotypes to optimum farming systems as an

	essential link in the development of new varieties by PBA.
Improving weed management in pulse crops through herbicide tolerance (DAS00131)	A lack of herbicide options in pulse crops limits weed control, production and area sown. This inability to adequately control weeds in pulses affects their adoption and role in farming systems, particularly given that the prevention of weed seed set in these crops is a vital tool in weed management. Suitable and safe herbicides are limited in pulses, especially for the post emergent control of broadleaf weeds, with many registered herbicides having a narrow crop safety margin. This project will develop and supply to PBA, germplasm with improved tolerance to registered herbicides and tolerance to new herbicides leading to the generation of varieties that will assist in increasing the productivity and profitability of pulses in Australia. Project Outputs: 1. Chickpea (desi and kabuli) lines with at least 1 novel source of herbicide tolerance, field validated and delivered to PBA. The novel herbicide target decided in consultation with industry. 2. Development of herbicide tolerant lentil germplasm from putative tolerant lines (metribuzin) developed in a previous project. Lines screened for tolerance and the most promising of these lines will be multiplied and validated through glasshouse and field dose response experiments to identify agronomically useful level of tolerance for use by the PBA lentil breeder. 3. Selections showing low levels of damage from dicamba (faba bean and lentil) and carfentrazone-ethyl and isoxaflutole (lentil) mass field screens multiplied and assayed for tolerance under controlled conditions. Lines showing useful levels of improved tolerance will be multiplied and validated in dose response and field experiments and those with agronomically useful levels of improved herbicide tolerance delivered to PBA breeders. 4. Development of cost effective, repeatable and non-destructive screening methods for stacking of herbicide tolerances in pulses and the subsequent development of lentil and faba bean germplasm with multiple herbicide tolerances. 5. Screening methods, including the use of diagnostic markers where applicable, developed to rapidly and non-destructively identify lines from opportunistic crosses aimed to specifically improve levels of herbicide tolerance. 6. Identification of other potentially useful herbicides for screening in pulse mutant populations. 7. In consultation with industry, appropriate herbicides will be identified for future screening.
Collection, phenotyping and exploitation of wild Cicer genetic resources for chickpea improvement (CSP00185)	While chickpea production has expanded dramatically over the last decade to become Australia's most valuable pulse export, the Mediterranean regions in the south and west have not recovered their earlier position as the dominant production areas for this crop. In addition to Ascochyta, Mediterranean production regions pose specific adaptive challenges such as terminal drought, low temperatures during flower and podset, salinity and low pH (particularly in WA). Genetic solutions to these constraints will accelerate the spread of chickpea throughout Mediterranean Australia and address grower demands for more diverse rotations incorporating a profitable grain legume. Chickpea improvement is constrained by limited genetic and adaptive diversity, and there is a need to increase the pool of germplasm that breeders can draw on in order to develop improved varieties adapted to Southern and Western cropping regions. This project seeks to strengthen chickpea breeding efforts and act as model for the exploitation of wild genetic resources by: 1. Targeted collection to widen the habitat range and genetic diversity of existing collections 2. Extensive phenotyping of traits prioritized as limiting Mediterranean adaptation 3. Coordinating wild Cicer-based phenotyping and population development projects in Australia and Turkey, linking these with international collaborations involving the USA, Canada, Ethiopia and India.
Identifying low pH tolerance and effective rhizobia for wild Cicer to improve adaptation to acid sandy soils (UMU00044)	The objective of research undertaken in this project is to determine if there are wild relatives of chickpea (C. arietinum L.) that could grow on acid sandy soils (pH CaCl2 below 5.5 - the current recommended soil acidity threshold for successful chickpea production). These accessions then have potential to be included in the chickpea breeding program specifically to target acid soils in Western and Southern cropping regions. Consideration is currently being made to vary to the existing UMU00044 project to expand the range

	of soils targeted to include more moderately acidic soil types. Specifically, the variation would enable the project to evaluate the suitability of existing wild Cicer germplasm for loam to clay-loam textured soils where cropping practices have led to moderate surface acidification.
Improving the profitability of pulse production through local validation of research outcomes in the Southern Region (to be contracted)	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.
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.	Pulse crops have long been recognised as providing numerous economic and farming system benefits including: biological nitrogen fixation; providing a disease break for some foliar and soil-borne pathogens; enabling increased diversity in weed management; and providing agronomic and economic diversity in enterprise mix. Whilst immediate opportunities for expansion in pulse area in the Southern Region may be apparent, and are in-fact occurring, the willingness of growers to adopt is often limited due to a range of factors including: perception of risk and complexity in production; concerns over the longer-term sustainability of pricing as Australian production increases; lack of local agronomic knowledge and support; agronomic challenges relating to disease, weed and pest management; seed-cleaning, storage and marketing issues; and required investments in plant and infrastructure. Pulses are considered by many to be complex to manage and poor agronomy subsequently poses a risk to the profitability of inexperienced growers. The present shortage of specialised knowledge and skills relating to pulse crop agronomy within industry necessitates targeted investment in capacity building within the advisory sector to build future industry leaders and provide agronomic support to growers through the multiplier effect. In building this capacity special consideration needs to be given to the demand on existing recognised experts within the pulse industry, specifically key personnel within the research community. In addition, a targeted program to directly build the skills, knowledge and confidence of growers in the production of high value pulse crops, focusing upon lentil and chickpea, is required to hasten the successful expansion in area planted to these crops in the Southern Region. It is proposed that a participatory approach to knowledge transfer is implemented, targeted to identified geographical areas for expansion where these crops may be well adapted. 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.
Validating recent research on break crop options in the low rainfall zone to	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

determine the best options for the different climate, soil type and biotic stress situations (DAS00162-A)	4. Extend the information generated to growers and advisers

Issue No. 5 - Farm business management skills are essential to improving long term profitability

Improved farm business management skills will improve long term profitability of grain growers in the low rainfall zone. Identified farm business skills which are essential to enduring profitability include risk management, economics of machinery investment, understanding the trade-off between investment in machinery and labour, tools and skills for better farm decision making, people management, assessing farm business performance, business planning, farm business succession, farm business models and pathways for entry into farming. Peer farmer learning groups are seen as an effective vehicle for improving farm business management skills.

GRDC investments addressing this issue

GRDC Farm Business Updates – Southern Region (ORM00015)	The GRDC Farm Business Updates (FBU) for advisers and growers provides a unique forum to learn from and network with leading growers and industry professionals. The program has a broad range of topics delivered by an outstanding selection of expert speakers. It provides topical and practical advice and information on the key issues facing grain growers and their advisers, including managing risk and business resilience. This three-year project provides: • FBU for Advisers (One day program; four per annum): to be held in strategic locations to maximise accessibility by advisers; • FBU for Growers (One day program; four per annum): at locations maximising accessibility of events to growers, to be reviewed annually with assistance of the Update Planning Committees and local grower groups; • Adviser FBU Newsletter (Four page – A4; six per annum): Targeted and distributed directly to advisers; • Farm Business Management Fact Sheets (four per annum); • FBM Ground Cover Articles (One page; six per annum); • Coordination and facilitation of the production of crop enterprise gross margin guide for the GRDC southern region by relevant agriculture agencies in each State Activities/products accessible via the GRDC website to extend the impact of the Updates across the entire year include event planning; schedules; registration (via link to ORM website); papers as included in proceedings; presentation slides; integrated presentations (video + slides; social media and direct e-mail to event attendees (past and current).
The integration of technical data and profit drivers for more informed decisions (RDP00013)	This national project is being delivered across the 14 major grain zones in Australia through the collection of more than 300 benchmarking datasets in collaboration with five consulting organisations. These benchmarking datasets have been analysed to identify the key management affected profit drivers by agro-ecological zone. The quantitative benchmarking analysis has also been complemented by a qualitative survey process with grain growers across each region. A consistent message from the results is that there is a large gap in financial performance between the top 20% businesses and the average business in each zone and there is abundant opportunity to increase profit from the resources that growers have available to them. Adapting to manage key production and business risks is an important characteristic of successful and sustainable farm businesses. To quantify differences in risk profile between the top 20% producer and the average business in each dataset the project undertook some modelling using @Risk software. This quantified that the top 20% businesses have a lower risk profile and a lower probability of incurring operational losses in comparison to average businesses. There are a range of management affected profit drivers that can be influenced to increase profit in cropping businesses across the SA Mid North, Lower Yorke Eyre and the SA – Vic Mallee agro-ecological zones. Most of these profit

	drivers are within the control of the farm manager providing significant opportunity for increased productivity. Proactively influencing the identified profit drivers will enable businesses to increase financial performance and reduce risk.
Practical financial figures for farm business management – aka Ag Profit (APR00001)	Continuing increases in volatility in key areas of the farm business sector exposes farmers to greater challenges in managing the financial risk to their business. Currently there are limited resources available to both farmers and Industry to assist farmers in improving their farm business management capability. The objectives of this project are to: 1. Increase awareness of the need for sound farm business management practices; 2. Facilitate the integration of business advisers (including regional accountants) into the development of industry farm business management strategies and initiatives; 3. Maintain innovative data analysis reporting outputs through input from well-regarded contributors from diverse geographic, rainfall and irrigation areas; 4. Provide a farm business data collection, storage, analysis, reporting and training service at a commercially accepted quality so that accountants are sufficiently enthused about 'partnering' with Ag Profit to promote this service to their clients; 5. Increase the number of growers participating in the project database application so that data analysis reporting can be of an increasing statistical quality; and 6. Securely manage all business data so as to avoid any breach of privacy.
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.
Rural R&D for Profit — Seasonal forecasting	The purpose of the program is to bridge the gap between seasonal climate forecasts and farm business decisions, and to improve productivity and profitability. The program will: • define the critical seasonal climate risk information needed by Australian farmers • improve understanding of the usefulness of seasonal climate forecasts and how to incorporate these into business decision making • provide seasonal climate information which can be tailored to individual needs • improve seasonal climate forecast skill in agricultural areas. The program plan addresses the following three priorities: Valuing the forecast. It is very difficult to assess how to use a forecast in a meaningful way if a person doesn't know how useful (valuable) a forecast is for a certain region at a given time. This is particularly true because forecasts are usually presented in probabilities, which are difficult to understand, especially for on-farm decision-making. Using the forecast. We know that farmers have higher profits if they better understand what a forecast actually means, and how to use that forecast to manage risk. This is achieved when farmers minimise losses in bad years and maximise returns in good years. Improve the ACCESS-S forecasting model. It's fundamental that any improved use of forecasts must be

	accompanied by improved forecasts. This area of the project aims to correct biases within Australia's seasonal forecasting model, ACCESS-S, in relation to atmospheric convection. Fixing the biases will deliver forecasting benefits across Australia, particularly in regional areas.
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.
Stubble Initiative – BCG (BDW00024) – Milestone 34	Whole farm analysis model developed. The data obtained from the project and case study farms will be collated and simplified into a whole farm analysis model that allows advisers to estimate the implications and benefits of investing into equipment required to retain stubble for individual clients in their region. Two training courses will be run to familiarise advisers with the model. Copy of resulting model and relevant outputs to be provided to GRDC.
Extension of knowledge and resources to manage risk and exploit opportunities to improve whole farm profit through successful integration of cropping and livestock enterprises in the GRDC Southern Region (to be contracted)	The aim of this investment is to provide growers and advisers across the GRDC Southern Region with information and tools to identify opportunities and strategies to better integrate cropping and livestock enterprises and increase the profitability and resilience of the whole farm business. This will be achieved by conducting extension and communication activities to increase awareness and further extend the research outcomes, tools and information previously generated by the G&G program to build grower and advisor skills and knowledge, and drive adoption of improved management practices. The investment will also include strategic update and improvement of existing tools and resources as detailed in the project outputs.
Grain and Graze III – Extension and deliver on mixed farm benefits in the Southern Region (SFS00028)	Grain and Graze 3 is the third phase of mixed farming investment by the GRDC. While farming systems and enterprise mixes vary across the low, medium and high rainfall zones, there are common issues addressed by this investment. They are: 1. <u>Smarter grazing of crops and stubbles to optimise business and production risk and increase profit -</u> The Grazing Cropped Land booklet has drawn together all results funded through the Grain and Graze program since 2003 and provides the most up to date material on grazing crops. Results from the many grazing crop demonstrations conducted in 2015 are supported by findings in the booklet. 2. <u>Better manage crop and pastures (within) a rotation to improve crop and livestock production -</u> Trialling and demonstrations have shown the potential to sow canola and wheat with strong vernalisation requirements as a fodder and grain crop. The practice involves spring or opportunistic summer sowing of the crop, using the early growth for grazing and then taking the crop through for grain. A second area is around the best choice of a fodder rotation option to manage emerging issues of weeds, nitrogen depletion and soil conditions through continuous cropping. The project has shown there are options around what can be sown, with varying benefits for weed control, nitrogen and soil however the complexity of the decision means many growers and advisors avoid trying something different. While the project is extending this knowledge, we are recognising an emerging need to develop a support tool to help work though the complexity of the rotation decision. 3. <u>Farmers making informed decisions about farm business mix that best meets their needs -</u> The

	Farm Decision Making booklet has provided an extremely valuable resource to discuss farm decision making. A facilitation guide has also been created to assist people who wish to try the exercises with their clients or in a discussion group or workshop. Aspects of risk assessment have also been advanced, with @risk training of 25 consultants and the development of the agprice guide. Other tools have been developed to assist in this area. The whole farm decision model provides an excellent resource to discuss decision making and the materials on farm boards is being sought by growers and advisors. The focus of risk and decision making has made many growers and advisors more aware of what influences their decisions and how this can be improved. Facets of the decision making theme are being used in other GRDC projects e.g. WA frost initiative. Risk analysis developed in the Grain and Graze program is now being used by private consultants throughout the country.
Grain and Graze II – Farm business logic application (NR00009)	The desired outcome of this project was to enable Australian grain growers to manage farming systems that are able to respond and adapt to changing environmental and market conditions to optimise risk and deliver an increase in profitability. This was achieved through: 1. Knowing the important business drivers - an improved understanding by growers and advisors of the risks within key farming practices in each agro-ecological zone. 2. Managing systems risk - Increased business profit (above the five year rolling average) by managing risk across seasons, between enterprises and major crops within the farming system 3. Managing individual crop agronomy - Optimise profit from the major crops grown in each agro-ecological zone by managing risk within crops. Three practice changes were identified to achieve the outcomes. 1. Identify and quantify the current risk in the business, the farmer's position on risk and the key risky business drivers. 2. Application of the knowledge about the risk position of the business and the farmer to shape the business direction both in the long term and short term. 3. Make/advise on tactical (operational) decisions that take into account the risk profile of the business, farmer, markets and the season.

Issue No. 6 - Robotics provide opportunities to increase efficiencies and profitability of farm businesses

The technology of robotics is advancing rapidly and offers a greater level of automation which may provide significant opportunities to increase efficiencies and profitability of farm businesses.

GRDC investments addressing this issue

Future Farm Program	The Future Farm Program, a bold and multi-faceted initiative that has been designed to help Australian agriculture become more efficient and sustainable through improved use of data and technology. Funded jointly by the GRDC and the Cotton Research and Development Corporation, the four-year program is divided into three themes: • Theme 1 - Intelligent Sensing • Theme 2 - Intelligent Decisions • Theme 3 - Intelligent Infrastructure Its major partners include CSIRO, Queensland University of Technology, the University of Sydney, the University of Southern Queensland and the Victorian Department of Economic Development, Jobs, Transport and Resources. Here we look at the objectives and methodology of each theme.

Issue No. 7 – New and novel methods of weed control

There is a need to develop alternatives to herbicides to control weeds where control with herbicides is no longer effective, and to prolong the life of existing herbicides.

GRDC investments addressing this issue

Development of new non-chemical weed control technologies – microwave control of weeds (UM00053)	This project has revealed that understanding the potential of microwave weed and soil treatment is not trivial. Clearly, microwave energy can kill weed plants. It can also kill weed seeds in the soil; however, this requires much more energy than is needed to kill plants. Therefore, the question of "commercial viability" for the technology does not have a simple answer. Increasing available power will proportionally decrease treatment time; however, there is a design challenge to make very powerful microwave systems portable. Therefore, should this technology become commercially available, it will probably rely on more powerful microwave generators than have been used in the current research programme. High power microwave generators, up to 100 kW, are commercially available, so this is a viable consideration. During the course of this project, a novel microwave applicator that restricts the volume of plant and soil matter being heated during treatment has been developed. This novel applicator significantly reduces the total energy requirements for weed plant treatment and has some influence in the very top layers of soil, if it is placed on direct contact with the soil. The engineering trade-off for reducing the overall energy requirements for treatment is a spatially restricted field distribution from the applicator, compared to the more traditional horn antenna. This field restriction is a very favourable feature with regard to: health and safety; and reduction of interference with other systems. However, it requires the applicator to be in close proximity to the soil surface for it to be effective against weeds and their seeds in the very surface layer of the soil. Irrespective of the final choice of applicator, the final prototype designs and specifications should be subjected to appropriate auditing procedures to fully determine the system's status according to the Defence and Strategic Goods List. Currently microwave heating is listed as a dual application technology and should not be restricted in terms of development and export; however, this should be evaluated when a semi-commercial prototype has been fabricated and tested. Negotiation are being continued for future investment and commercialisation including use in robotic applications.
Mechanisms of Weed Suppression By Early Vigour and Other Novel Wheat Genotypes (USC00022)	In conjunction with GRS100926 1. Assess the competitive traits of selected superior Australian winter wheat genotypes which are well adapted for the southern taming region 2. Assess the impact of environmental factors such as moisture and temperature on weed suppressive ability of wheat 3. Assess and measure wheat metabolites involved in weed suppression and 4. Measure weed suppression by wheat stubble post-harvest
Grains Industry Research Scholarship - David Hall (QUT) - Automated Weed and Plant Recognition for Agricultural Applications (GRS10926)	The expected outcome of this project is a robust, plant recognition system which can be applied within an agricultural setting. This outcome corresponds to the "Protecting your crop" investment theme outlined in GRDC's Strategic Research & Development Plan 2012-17 as it can be used for in crop weed detection and management systems. Research expects to develop new plant detection and classification technologies which can be used as part of either an automated weed destruction system or an automated surveying system on a mobile ground platform. This system is expected to overcome the problems involved with applying such a system, such as the need to work in real-time, dealing with challenging conditions, and being adaptable to new crops and introduced weed species.

Issue No. 10 - Predicting flowering time and manipulating crop development to reduce exposure during high risk periods to mitigate impact of frost

The ability to predict flowering time and the risk of frost (and heat stress) given sowing date for different locations across the Southern Region would mitigate the risk of losses caused by frost. A greater understanding of the effectiveness of techniques to manipulate development, flowering and maturity of varieties which can reduce exposure to high frost risk periods.

GRDC investments addressing this issue

Screening of frost tolerance in cereals (UA00162)	Trait diversity study looking for variation in the frost tolerance traits amongst exotic germplasm (182 wheat lines). Traits examined include photoperiod, vernalisation and basic vegetative phase (all fundamental drivers of flowering time).
Identification of wheat frost tolerance loci using a combination of genetics, biochemistry and molecular approaches (CSP00202)	Identifying cold tolerance QTL's to enable development of gene and metabolite markers that can be deployed in breeding programs to more accurately screen for frost tolerance in wheat.
Determining yield under frost- one degree at a time (DAW00234)	Research to evaluate the relationship between the levels of frost induced sterility and yield loss in wheat in the Southern, Western and Northern regions. Project will identify cultivars that have a greater ability to compensate for loss of floret fertility after frost (i.e. compensation responses relating to late tillering, grain number set, and grain size).
Advancing profitable farming systems - frost risk management (DAW00260)	Research evaluating the effect crop type, stubble management, and canopy management has the degree in crop damage incurred as a result of frost. Findings will be used to help growers and consultants make more informed decisions about agronomic practices to reduce the effects of frost on yield.
Spatial temperature measurement and mapping tools to assist growers, advisors and extension specialists manage frost risk at a farm scale (CSP00198)	Research to evaluate the feasibility and accuracy of utilizing new technologies to rapidly assess damage (post frost) to estimate yield loss and make post frost management decisions (e.g. cutting hay). Technologies examined will include UAV's, satellite, and spatial information.,
NFI knowledge and communication manager (SKC00008)	NFI knowledge manager provides timely accurate distribution of key extension and communication material such as: frost fact sheets, frost incident management plans. This consultant is also responsible for establishing the online community of practice for frost management.
Advancing profitable farming systems – frost risk management (DAW00241/260)	Effects of plant growth regulators on wheat under frost (Dicarboxylic acid, terpene polymers- both anti-transpirants, di-1-p-menthene, moddus evo)
Management of wheat and barley cultivars in WA (DAW00224)	Characterising 182 lines - photoperiod, vernalisation and basic vegetative phase- fundamental drivers of flowering time and update the FlowerPower decision-support tool for the Western Region. N.B. FlowerPower app is not relevant for Southern Region.

Issue No. 12 - The sustainable use of cost effective herbicides and the development of alternative management tools are critical for effective weed control and profitability of cropping systems

The over reliance on Group B herbicides for grass and broadleaf weed control, increasing herbicide resistance in broadleaf weeds such as Indian Hedge Mustard and Sow thistle, and the selection for resistance in a range of other weeds as a consequence of exposure to herbicides will continue to limit cost-effective chemical weed control and the profitability of growers. The development of a range of alternative chemical and non-chemical weed control strategies, such as new or additional herbicide tolerance for a greater range of crop options and varieties and develop new and novel cultural technologies

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Development of new non-chemical weed control technologies – microwave control of weeds (UM00053)	This project has revealed that understanding the potential of microwave weed and soil treatment is not trivial. Clearly, microwave energy can kill weed plants. It can also kill weed seeds in the soil; however, this requires much more energy than is needed to kill plants. Therefore, the question of "commercial viability" for the technology does not have a simple answer. Increasing available power will proportionally decrease treatment time; however, there is a design challenge to make very powerful microwave systems portable. Therefore, should this technology become commercially available, it will probably rely on more powerful microwave generators than have been used in the current research programme. High power microwave generators, up to 100 kW, are commercially available, so this is a viable consideration. During the course of this project, a novel microwave applicator that restricts the volume of plant and soil matter being heated during treatment has been developed. This novel applicator significantly reduces the total energy requirements for weed plant treatment and has some influence in the very top layers of soil, if it is placed on direct contact with the soil. The engineering trade-off for reducing the overall energy requirements for treatment is a spatially restricted field distribution from the applicator, compared to the more traditional horn antenna. This field restriction is a very favourable feature with regard to: health and safety; and reduction of interference with other systems. However, it requires the applicator to be in close proximity to the soil surface for it to be effective against weeds and their seeds in the very surface layer of the soil. Irrespective of the final choice of applicator, the final prototype designs and specifications should be subjected to appropriate auditing procedures to fully determine the system's status according to the Defence and Strategic Goods List. Currently microwave heating is listed as a dual application technology and should not be restricted in terms of development and export; however, this should be evaluated when a semi-commercial prototype has been fabricated and tested. Negotiations are being continued for future investment and commercialisation including use in robotic applications.
Improving IWM practice of emerging weeds in the southern and western regions (UA00149)	This project will provide new tools that will allow better understanding and control of summer weeds: fleabane, windmill grass, feathertop Rhodes grass, tar vine, button grass and sow thistle/milk thistle, in the Southern and Western Regions. It will also provide new tactics for the control of herbicide-resistant wild radish, barley grass, brome grass and Indian hedge mustard in the Southern and Western Regions. Research seeking to understand the incidence, density and emergence patterns of emerging summer weeds (fleabane, sowthistle, windmill grass, feathertop Rhodes grass, button grass and tar vine) has shown that these species are becoming widespread across the grain growing regions. They prefer to germinate from the soil surface, meaning they become more common in no-till systems. Most species have a wide temperature range for germination, meaning they can emerge at any time of the year when conditions are favourable. However, in Mediterranean environments they tend to emerge during spring and persist into summer. Generally, these species have low levels of seed persistence in the seed bank and seed banks can be exhausted within 12 months, provided effective control occurs. Control studies have shown that common summer fallow herbicide applications are generally not effective. Double knock applications are more effective. Pot studies and field trials show that residual herbicides applied during winter can reduce emergence of these weeds in spring and where registered may prove more effective than relying on summer sprays. Crop competition in the cereal phase is also helpful at reducing population numbers in summer. Control of herbicide resistant wild radish requires a 2 spray approach to be effective. One spray needs to be applied early, either as a pre-emergent or an early post-emergent application. Due to its persistent seed bank, at least 3 years of effective control are required to run down seed banks. Control of herbicide resistant barley grass requires the use of effective pre-emergent herbicides along with crop competition in cereals and crop-topping in pulse crops and pastures. Glyphosate resistance in some species, such as fleabane, windmill grass and feathertop Rhodes grass, is occurring on roadsides and may move from there into cropped fields.

	The results of the research are being delivered to growers through field days, fact sheets, GRDC Updates and other avenues.
Surveillance of herbicide resistant weeds in Australian grain cropping (UCS00024)	Between this project and UCS00020 all grain regions are being surveyed once every 5 years for HR status of major winter weeds.US00070 is starting on summer weeds and fallows. Glyphosate resistance weeds form fallows is being identified through UWA00171 (AHRI) and UA00158 as well as recorded in ARN0001 (AGSWG). This research will seek to understand the incidence of herbicide resistance across the cropping region of Australia. This will occur through surveys in which randomly selected cropping paddocks will be visited and seed of common grass or broadleaf weeds collected. Grass weed species will include annual ryegrass, wild oats, brome grass and barley grass. Broadleaf weeds will include wild radish, Indian hedge mustard, wild turnip, fleabane and sowthistle. Other weeds present at high frequencies will also be collected. The weeds collected in the three regions (Northern, Western and Southern) may vary between regions due to differences in cropping programs, climatic conditions and weed diversity. These weeds will then be screened for resistance to a wide range of herbicides commonly used for their control. Southern region starts in 2018.
Weed management in the southern region mixed farming systems - strategies to combat herbicide resistance (UCS00020)	To perform extensive surveys to assess herbicide resistance in cropping regions across NSW, VIC, SA and TAS. To perform field and greenhouse experimentation to evaluate management factors that influence weed epidemiology or presence in southern region mixed cropping zone. To determine novel chemical and non-chemical approaches for management of weeds in cereal and pulse crops and report these findings to APVMA to assist in registration or labelling of new products/strategies for improved weed management of winter annual weeds. Surveys for screening of key herbicide resistant weeds, including annual ryegrass, bromegrass, wild radish, Indian hedge mustard, sowthistle, windmill grass, fleabane and barley grass have been conducted across 3 of 5 regions to be screened in 2013, 2014 and 2015 as outlined in project methods across NSW, VIC, TAS and SA, using standard seed collection protocols. Upon completion of random survey transects used for seed and plant collection, seed was properly cleaned and prepared for herbicide resistance testing. Herbicide resistance testing was performed for all samples collected. To date, results have shown that resistance levels to annual ryegrass and in some cases bromegrass and wild oats have increased in the past 5 years across NSW, VIC, TAS and SA. Levels of resistance to selected herbicide families were typically higher in SA and western VIC in contrast to TAS, NSW and eastern VIC. Field research sites were identified in NSW and SA for research outlined in outputs 2 and 3 (weed epidemiology of key weeds in the southern region, and use of new chemical and novel strategies for weed management) as outlined in project methods. Research has been performed on management strategies for annual ryegrass, bromegrass, fleabane, and witchgrass spp. in particular, using both chemical and non-chemical strategies. Rotational strategies that included lucerne, phalaris/clover, or canola in a two year rotation resulted in reduced weed infestations in 2 locations across NSW. In SA, rotations that included lupins or TT canola over a 2 year period resulted in reduced bromegrass seedset. Competitive crop cultivar experiments were performed over 2 years with diverse cultivars of canola (NSW,SA) as well as barley and wheat (NSW locations). Canola GT50 and newly released cultivars proved highly suppressive in crop and post-harvest. Selected barley and wheat cultivars (Condo, Espada, Federation, Hindmarsh) proved particularly suppressive in crop. Weed suppression was associated with early crop vigour and reduced light penetration at the soil surface due to canopy architectural traits. Canola and certain grazing wheat cultivars showed potential for weed suppression associated with crop residues post-harvest, potentially due to allelopathic activity associated with production of bioactive metabolites in the soil rhizosphere. Herbicide resistant pulse crops are under investigation at CSU and UA for their ability to suppress difficult to manage weeds using a variety of herbicide tools, in both glasshouse and field experiments.
New uses for existing chemistry (UQ00080)	The overall objective of the project is to identify new uses for existing registered pre- and post-emergent herbicides for the site-specific management of feathertop Rhodes grass (FTR), awnless barnyard grass (ABYG), fleabane, sowthistle, brome grass, barley grass, and wild radish present in crop and fallow situations. Pot and field trials were conducted to explore the potential for the use of older herbicides either alone or in mixtures for the control of feathertop Rhodes grass (FTR), awnless barnyard grass (BYG),

	fleabane, common sowthistle, barley grass, brome grass, and wild radish in different regions. The mixture of Product A plus Avadex Xtra provided suppression of brome grass in barley. Sakura plus trifluralin and high rates of Product B were the most effective herbicide for pre-emergent control of barley grass. A number of mixtures and sequential applications were found effective in controlling common sowthistle and flaxleaf fleabane. Three tank-mix treatments effectively controlled awnless barnyard grass; however, sequential applications exhibited higher levels of control. Herbicide tank mixtures and sequential applications were not effective on mature feathertop Rhodes grass under field conditions. Fluridone (Group F) showed promising results for wild radish control.
Emerging weeds (UA00156)	Document current knowledge on seed dormancy, life cycles and longevity, assess the relevance of this data to contemporary farming systems, and identify knowledge gaps for the major emerging weed species and identify knowledge gaps and RD&E needs. 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. This trait of weed species will have a major effect on the success of harvest seed collection.
Australian Herbicide Resistance Initiative - Phase V (UWA00171)	Sub Project investigating targeted tillage and also focussing on low seed bank farming systems and corresponding ecological weeds changes Australian grain growers, like their counterparts in other industrialised nations continue to rely on herbicides as the most important component of their weed management strategy. In the foreseeable future there are no alternative technologies in world cropping that will achieve the results that herbicides obtain. It is now understood that novel mechanisms of resistance to different herbicide modes of action exist and will continue to evolve under global herbicide selection - a better understanding of the factors and dynamics of herbicide resistance selection will delay the evolution of herbicide resistance in weeds. Evolutionary biology and Darwinian evolutionary theory provide a very powerful framework to interpret and understand how weeds can respond to herbicide use and other pressures in modern cropping systems. Improved crop/weed management strategies evolving from increased knowledge and understanding of the herbicide resistance phenomenon will ultimately benefit the Australian grains industry and represents a significant contribution towards achieving sustainable cropping systems. In AHRI, the 2015-2020 project encompasses three research programs; Resistance Evolution, Resistance Mechanisms and Resistance Management, plus a Communications program. All programs have a high level of engagement in delivering activities in all three GRDC regions. **1 - Resistance evolution:** Essential for monitoring on-going herbicide sustainability, field survey work will quantify herbicide efficacy and herbicide resistance evolution in key cropping weeds. Resistance surveys have been conducted for Ryegrass, Wild oats, Barley grass, Brome grass, Wild radish and Fleabane and testing for resistance has commenced. Ongoing research to highlight the importance of maintaining optimum herbicide efficacy (rates) has commenced together with evolution studies to predict the onset of resistance to new herbicides, ways to delay resistance onset and resistance management techniques. This information will be captured in the PERTH and RIM models for use in Australian cropping and disseminated widely. **2 - Resistance mechanisms:** Understanding how Australian crop weeds achieve resistance to powerful herbicides is of benefit to the nation and globally. AHRI is the international leader in this research area and attracts considerable ARC grant funding and industry support

	AHRI is working to establish the biochemical and molecular genetic basis of novel herbicide resistance in Australian major crop weeds and to ensure this information is widely disseminated and, when relevant, incorporated into management strategies. This fundamental AHRI biochemical/molecular research underpins an understanding of how to sustainably manage herbicides and minimise resistance. **3 - Resistance management**: The focus of this program is aimed at maximising crop production/sustainability while minimising crop-weed and herbicide resistance problems in Australian grain crops. This program has a national focus with the development of weed control solutions to fit cropping systems in each of the Western, Southern and Northern production regions. Harvest weed seed control (HWSC) systems have been developed as a major AHRI activity in response to the escalation in herbicide resistance and because of an identified opportunity to target weed seed production during grain crop harvest. The major annual weeds infesting Australian cropping; annual ryegrass, wild radish, brome grass and wild oats, all retain high proportions of their seed production at maturity. This attribute (biological weakness) is taken advantage of by targeting this seed for collection (harvested) during commercial grain crop harvest (Walsh and Powles 2007). **4 - Communication:**. AHRI is committed to delivering AHRI's and other relevant research to the Australian broadacre cropping industry in an engaging manner, promoting greater awareness of herbicide resistance and educating industry stakeholders on strategies to increase crop yields and sustain herbicides. Tools to communicate AHRI messages include delivery of website, online courses, live webinars, face-to-face presentations, social media and targeted events.
WeedSmart (UWA00172)	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.
Genetically improving wheat's ability to outcompete weeds (CSP00182)	To develop germplasm and methodologies aimed at delivery of wheats with improved weed competitiveness. Research here is advanced with regular communication in engaging breeders in identifying suitable commercial varieties, and testing/developing sources of improved early vigour for use in crossing and population development. Crosses using alternative dwarfing gene sources and deployment of molecular markers have facilitated large numbers of lines to be advanced. Phenotyping methods aimed at improved and robust high-throughput selection are being developed with the aim to deliver to commercial breeding programs targeting improved weed competitiveness. Note: weed competitive traits is a low priority for breeders.
Mechanisms of Weed Suppression By Early Vigour and Other Novel Wheat Genotypes (USC00022)	In conjunction with GRS100926 1. Assess the competitive traits of selected superior Australian winter wheat genotypes which are well adapted for the southern taming region 2. Assess the impact of environmental factors such as moisture and temperature on weed suppressive ability of wheat 3. Assess and measure wheat metabolites involved in weed suppression and 4. Measure weed suppression by wheat stubble post-harvest
Cultural Weed Management (being contracted)	Project to ascertain best bet combinations of cultural and chemical weed control tactics for each agro-ecological sub region.

	Herbicides remain the primary method of weed control in cereal crops because they are very cost effective, hence why farmers are reluctant to adopt integrated weed management (IWM) until they have a serious herbicide resistance problem. When resistance exists, farmers generally change to other modes of herbicide action (including herbicide-resistant crops); however, when resistance to multiple modes of action exists, farmers are forced to adopt more radical nonchemical or cultural control options. Crop competition is widely accepted as an important tactic for suppressing weed growth and maintaining crop yield. Agronomic choices influence crop competition, including crop species and cultivar, row spacing, crop density and row orientation. All these tactics have been shown to impact on the control of in-crop weeds. For wheat, while cultural factors such as row spacing, seeding rate, row orientation, nutrient placement, time of sowing and swathing/time of harvest are known to contribute to effective weed management, these management tactics have not been studied extensively in factorial combinations in different environments to demonstrate their relative contributions in a farming system. While significant effort has been focused on competitive agronomy in wheat and other cereals, much less effort has gone into crops such as canola. To advance this research, it is expected that more data will be needed on existing genetic variability of competitive ability in canola x agronomic region x agronomic practice. Using a limited number of diverse canola genotypes validation data could be collected on the existing genetic variability of competitive ability x agronomic region x agronomic practice. Adopting a holistic systems approach should deliver more practical information to growers on likely outcomes of specific agronomic IWM strategies. Growers can then make informed investment decisions.
Locally important weeds (DAW00257)	This project will undertake research to quantify the biology and ecology of eight (8) locally important weed species, 4 in the western region and 4 in the southern region. The weed species have been selected following a consultation process with the Regional Cropping Solutions Network (RCSN) and major Grower groups, with the final input and decision coming from GRDC. Weed species include matricaria (Oncosiphon spp.), marshmallow (Malva parviflora), stinking lovegrass (Eragrostis cilianensis) and Feathertop Rhodes grass (Chloris virgata) in the western region and Lincoln weed (Diplotaxis tenuifolia), wild vetch (Vicia sativa), caltrop (Tribulis terrestris), and Lake Boga poppy (Hypercoum pendulum) in the southern region. These weeds are of local importance but have not been the subject of major prior research projects.
Grains Industry Research Scholarship - David Hall (QUT) Automated Weed and Plant Recognition for Agricultural Applications (GRS10926)	The expected outcome of this project is a robust, plant recognition system which can be applied within an agricultural setting. This outcome corresponds to the "Protecting your crop" investment theme outlined in GRDC's Strategic Research & Development Plan 2012-17 as it can be used for in crop weed detection and management systems. Research expects to develop new plant detection and classification technologies which can be used as part of either an automated weed destruction system or an automated surveying system on a mobile ground platform. This system is expected to overcome the problems involved with applying such a system, such as the need to work in real-time, dealing with challenging conditions, and being adaptable to new crops and introduced weed species.
Regional Agronomy SA – Improving weed management in high break crop intensity farming (DAS00168-BA)	1. Provide SA farming system groups, growers and their advisors with successful and sustainable integrated weed management strategies that allow effective weed control of the major weeds in high break crop intensity rotations which incorporate new herbicide tolerant break crop options, no-till and high stubble retention. 2. To build regional capacity through the training and retention <:i a skilled agronomist based at Clare which services the Mid North/Yorke Peninsula region of South Australia (SA) and supports other SA regional agronomists to deliver R,D & E project outcomes to all cropping regions of the state.
Mechanisms, evolution and inheritance of resistance (UA00158)	The expected outcome of the project is that by 2025, more than 90% of growers undertake activities to delay the onset of or manage herbicide resistance in weed populations based on a foundational knowledge of resistance mechanisms, evolution and inheritance. By 2020, 80% of growers are using and advisers are recommending integrated weed management practices. This project will do this through the delivery of new information on the mechanisms, inheritance and evolutionary dynamics of resistance to key herbicides, concentrating on glyphosate resistance in brome grass, barnyard grass, sowthistle and prickly lettuce; 2,4-D and diflufenican resistance in Indian hedge mustard; 2,4-D resistance in sowthistle; clethodim resistance in annual ryegrass; and resistance to the pre-emergent herbicides trifluralin, propyzamide, triallate and prosulfocarb in annual ryegrass.

Issue No. 15 - The downside risk of highly leveraged, high input, high crop intensity farming systems threatens the economic viability of low rainfall farm businesses.

A risk management feature of traditional low rainfall farm businesses has been the adoption of mixed farming practices, in part to minimise the financial impact of poor seasons. High cropping intensity systems adopted from higher rainfall districts can expose low rainfall businesses to higher risk. There is the need to improve the identification, development and quantification of practices which better balance the multiple goals of maximising profit, reducing risk and increasing business resilience.

GRDC investments addressing this issue

GRDC Farm Business Updates – Southern Region (ORM00015)	The GRDC Farm Business Updates (FBU) for advisers and growers provides a unique forum to learn from and network with leading growers and industry professionals. The program has a broad range of topics delivered by an outstanding selection of expert speakers. It provides topical and practical advice and information on the key issues facing grain growers and their advisers, including managing risk and business resilience. This three-year project provides: • FBU for Advisers (One day program; four per annum): to be held in strategic locations to maximise accessibility by advisers; • FBU for Growers (One day program; four per annum): at locations maximising accessibility of events to growers, to be reviewed annually with assistance of the Update Planning Committees and local grower groups; • Adviser FBU Newsletter (Four page – A4; six per annum): Targeted and distributed directly to advisers; • Farm Business Management Fact Sheets (four per annum); • FBM Ground Cover Articles (One page; six per annum); • Coordination and facilitation of the production of crop enterprise gross margin guide for the GRDC southern region by relevant agriculture agencies in each State Activities/products accessible via the GRDC website to extend the impact of the Updates across the entire year include event planning; schedules; registration (via link to ORM website); papers as included in proceedings; presentation slides; integrated presentations (video + slides; social media and direct e-mail to event attendees (past and current).
The integration of technical data and profit drivers for more informed decisions (RDP00013)	This national project is being delivered across the 14 major grain zones in Australia through the collection of more than 300 benchmarking datasets in collaboration with five consulting organisations. These benchmarking datasets have been analysed to identify the key management affected profit drivers by agro-ecological zone. The quantitative benchmarking analysis has also been complemented by a qualitative survey process with grain growers across each region. A consistent message from the results is that there is a large gap in financial performance between the top 20% businesses and the average business in each zone and there is abundant opportunity to increase profit from the resources that growers have available to them. Adapting to manage key production and business risks is an important characteristic of successful and sustainable farm businesses. To quantify differences in risk profile between the top 20% producer and the average business in each dataset the project undertook some modelling using @Risk software. This quantified that the top 20% businesses have a lower risk profile and a lower probability of incurring operational losses in comparison to average businesses. There are a range of management affected profit drivers that can be influenced to increase profit in cropping businesses across the SA Mid North, Lower Yorke Eyre and the SA – Vic Mallee agro-ecological zones. Most of these profit drivers are within the control of the farm manager providing significant opportunity for increased productivity. Proactively influencing the identified profit drivers will enable businesses to increase financial performance and reduce risk.
Practical financial figures for farm business management – aka Ag Profit	Continuing increases in volatility in key areas of the farm business sector exposes farmers to greater challenges in managing the financial risk to their business. Currently there are limited resources available to both farmers and Industry to assist farmers in improving their farm business management capability. The objectives of this project are to:

(APR00001)	1. Increase awareness of the need for sound farm business management practices; 2. Facilitate the integration of business advisers (including regional accountants) into the development of industry farm business management strategies and initiatives; 3. Maintain innovative data analysis reporting outputs through input from well-regarded contributors from diverse geographic, rainfall and irrigation areas; 4. Provide a farm business data collection, storage, analysis, reporting and training service at a commercially accepted quality so that accountants are sufficiently enthused about 'partnering' with Ag Profit to promote this service to their clients; 5. Increase the number of growers participating in the project database application so that data analysis reporting can be of an increasing statistical quality; and 6. Securely manage all business data so as to avoid any breach of privacy.
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.
Rural R&D for Profit — Seasonal forecasting	The purpose of the program is to bridge the gap between seasonal climate forecasts and farm business decisions, and to improve productivity and profitability. The program will: • define the critical seasonal climate risk information needed by Australian farmers • improve understanding of the usefulness of seasonal climate forecasts and how to incorporate these into business decision making • provide seasonal climate information which can be tailored to individual needs • improve seasonal climate forecast skill in agricultural areas. The program plan addresses the following three priorities: Valuing the forecast. It is very difficult to assess how to use a forecast in a meaningful way if a person doesn't know how useful (valuable) a forecast is for a certain region at a given time. This is particularly true because forecasts are usually presented in probabilities, which are difficult to understand, especially for on-farm decision-making. Using the forecast. We know that farmers have higher profits if they better understand what a forecast actually means, and how to use that forecast to manage risk. This is achieved when farmers minimise losses in bad years and maximise returns in good years. Improve the ACCESS-S forecasting model. It's fundamental that any improved use of forecasts must be accompanied by improved forecasts. This area of the project aims to correct biases within Australia's seasonal forecasting model, ACCESS-S, in relation to atmospheric convection. Fixing the biases will deliver forecasting benefits across Australia, particularly in regional areas.
Using seasonal forecast information and tools to manage risk and increase profitability in	Climate remains the single most important driver of farm productivity and profitability. While it is important that growers and advisors take a strategic approach and have robust farming systems that allow them to manage our variable climate, there may be an opportunity for more appropriate use of seasonal climate forecast information to inform tactical decisions by limiting downside risk and

the Southern Region (to be contracted)	maximising upside opportunity. Understanding the probabilities of rainfall and temperatures (i.e. very much below, below, average, above or very much above average) is essential to use seasonal forecasts to effectively inform farm decisions. Identifying any past years which are similar to the forecast outlook can provide users with a reference to understand the likely outcomes based on past experiences and learnings. However, it is recognised that for some forecasts it is either not possible or too simplistic to identify previous years which are similar. In addition to weather forecasts, measurable or predictable factors such as soil moisture or agronomic constraints are a major consideration for growers and advisors. The aim of this investment is to – 1. deliver a functional tool that provides a summary forecast and "expert" interpretation of rainfall and temperature outlook and the impact on soil moisture and other relevant information would provide growers and advisors with a practical resource to make better informed decisions; 2. establish a participatory pilot program to develop and promote tools to better use Bureau of Meteorology weather data and seasonal outlook forecasts and up-skill participating advisors to better understand the implications of seasonal forecasts and strategies to manage risk and increase profitability. Expected outcome - by February 2020, all growers, advisors and industry stakeholders in the GRDC Southern Region will have regular access to improved seasonal forecast information, emphasising the skill of the forecast and implications for farm management. A pilot program will up-skill a small group of advisors to identify, test and develop a framework to use seasonal forecast information to better manage risk and increase enduring profitability of grain growers.
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.
Stubble Initiative – BCG (BDW00024) – Milestone 34	Whole farm analysis model developed. The data obtained from the project and case study farms will be collated and simplified into a whole farm analysis model that allows advisers to estimate the implications and benefits of investing into equipment required to retain stubble for individual clients in their region. Two training courses will be run to familiarise advisers with the model. Copy of resulting model and relevant outputs to be provided to GRDC.
Validating recent research on break crop options in the low	The aims of this investment - • Summarise recent studies on break crop options in the published and grey literature;

rainfall zone to determine the best options for the different climate, soil type and biotic stress situations (DAS00162-A)	• Determine the best break crop options for different climate, soil type and biotic stress situations; • Develop improved agronomic packages to manage biotic stresses, and • Extend the information generated to growers and advisers
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.
Extension of knowledge and resources to manage risk and exploit opportunities to improve whole farm profit through successful integration of cropping and livestock enterprises in the GRDC Southern Region (to be contracted)	The aim of this investment is to provide growers and advisers across the GRDC Southern Region with information and tools to identify opportunities and strategies to better integrate cropping and livestock enterprises and increase the profitability and resilience of the whole farm business. This will be achieved by conducting extension and communication activities to increase awareness and further extend the research outcomes, tools and information previously generated by the G&G program to build grower and advisor skills and knowledge, and drive adoption of improved management practices. The investment will also include strategic update and improvement of existing tools and resources as detailed in the project outputs.
Grain and Graze III – Extension and deliver on mixed farm benefits in the Southern Region (SFS00028)	Grain and Graze 3 is the third phase of mixed farming investment by the GRDC. While farming systems and enterprise mixes vary across the low, medium and high rainfall zones, there are common issues addressed by this investment. They are: 4. <u>Smarter grazing of crops and stubbles to optimise business and production risk and increase profit -</u> The Grazing Cropped Land booklet has drawn together all results funded through the Grain and Graze program since 2003 and provides the most up to date material on grazing crops. Results from the many grazing crop demonstrations conducted in 2015 are supported by findings in the booklet. 5. <u>Better manage crop and pastures (within) a rotation to improve crop and livestock production -</u> Trialling and demonstrations have shown the potential to sow canola and wheat with strong vernalisation requirements as a fodder and grain crop. The practice involves spring or opportunistic summer sowing of the crop, using the early growth for grazing and then taking the crop through for grain. A second area is around the best choice of a fodder rotation option to manage emerging issues of weeds, nitrogen depletion and soil conditions through continuous cropping. The project has shown there are options around what can be sown, with varying benefits for weed control, nitrogen and soil however the complexity of the decision means many growers and advisors avoid trying something different. While the project is extending this knowledge, we are recognising an emerging need to develop a support tool to help work though the complexity of the rotation decision.

	6. Farmers making informed decisions about farm business mix that best meets their needs - The Farm Decision Making booklet has provided an extremely valuable resource to discuss farm decision making. A facilitation guide has also been created to assist people who wish to try the exercises with their clients or in a discussion group or workshop. Aspects of risk assessment have also been advanced, with @risk training of 25 consultants and the development of the agprice guide. Other tools have been developed to assist in this area. The whole farm decision model provides an excellent resource to discuss decision making and the materials on farm boards is being sought by growers and advisors. The focus of risk and decision making has made many growers and advisors more aware of what influences their decisions and how this can be improved. Facets of the decision making theme are being used in other GRDC projects e.g. WA frost initiative. Risk analysis developed in the Grain and Graze program is now being used by private consultants throughout the country.
Grain and Graze II – Farm business logic application (NR00009)	The desired outcome of this project was to enable Australian grain growers to manage farming systems that are able to respond and adapt to changing environmental and market conditions to optimise risk and deliver an increase in profitability. This was achieved through: 4. Knowing the important business drivers - an improved understanding by growers and advisors of the risks within key farming practices in each agro-ecological zone. 5. Managing systems risk - Increased business profit (above the five year rolling average) by managing risk across seasons, between enterprises and major crops within the farming system 6. Managing individual crop agronomy - Optimise profit from the major crops grown in each agro-ecological zone by managing risk within crops. Three practice changes were identified to achieve the outcomes. 4. Identify and quantify the current risk in the business, the farmer's position on risk and the key risky business drivers. 5. Application of the knowledge about the risk position of the business and the farmer to shape the business direction both in the long term and short term. 6. Make/advise on tactical (operational) decisions that take into account the risk profile of the business, farmer, markets and the season.

Issue No. 21 - Barley and Brome Grass control

Selection pressure for later germination and the development of herbicide resistance have caused Barley and Brome Grass to become significant weeds which constrains the profits of growers in low rainfall areas.

GRDC investments addressing this issue

Australian Herbicide Resistance Initiative - Phase V (UWA00171)	Sub Project investigating targeted tillage and also focussing on low seed bank farming systems and corresponding ecological weeds changes Australian grain growers, like their counterparts in other industrialised nations continue to rely on herbicides as the most important component of their weed management strategy. In the foreseeable future there are no alternative technologies in world cropping that will achieve the results that herbicides obtain. It is now understood that novel mechanisms of resistance to different herbicide modes of action exist and will continue to evolve under global herbicide selection - a better understanding of the factors and dynamics of herbicide resistance selection will delay the evolution of herbicide resistance in weeds. Evolutionary biology and Darwinian evolutionary theory provide a very powerful framework to interpret and understand how weeds can respond to herbicide use and

	other pressures in modern cropping systems. Improved crop/weed management strategies evolving from increased knowledge and understanding of the herbicide resistance phenomenon will ultimately benefit the Australian grains industry and represents a significant contribution towards achieving sustainable cropping systems. In AHRI, the 2015-2020 project encompasses three research programs; Resistance Evolution, Resistance Mechanisms and Resistance Management, plus a Communications program. All programs have a high level of engagement in delivering activities in all three GRDC regions. **1 - Resistance evolution:** Essential for monitoring on-going herbicide sustainability, field survey work will quantify herbicide efficacy and herbicide resistance evolution in key cropping weeds. Resistance surveys have been conducted for Ryegrass, Wild oats, Barley grass, Brome grass, Wild radish and Fleabane and testing for resistance has commenced. Ongoing research to highlight the importance of maintaining optimum herbicide efficacy (rates) has commenced together with evolution studies to predict the onset of resistance to new herbicides, ways to delay resistance onset and resistance management techniques. This information will be captured in the PERTH and RIM models for use in Australian cropping and disseminated widely. **2 - Resistance mechanisms:** Understanding how Australian crop weeds achieve resistance to powerful herbicides is of benefit to the nation and globally. AHRI is the international leader in this research area and attracts considerable ARC grant funding and industry support AHRI is working to establish the biochemical and molecular genetic basis of novel herbicide resistance in Australian major crop weeds and to ensure this information is widely disseminated and, when relevant, incorporated into management strategies. This fundamental AHRI biochemical/molecular research underpins an understanding of how to sustainably manage herbicides and minimise resistance. **3 - Resistance management**: The focus of this program is aimed at maximising crop production/sustainability while minimising crop-weed and herbicide resistance problems in Australian grain crops. This program has a national focus with the development of weed control solutions to fit cropping systems in each of the Western, Southern and Northern production regions. Harvest weed seed control (HWSC) systems have been developed as a major AHRI activity in response to the escalation in herbicide resistance and because of an identified opportunity to target weed seed production during grain crop harvest. The major annual weeds infesting Australian cropping; annual ryegrass, wild radish, brome grass and wild oats, all retain high proportions of their seed production at maturity. This attribute (biological weakness) is taken advantage of by targeting this seed for collection (harvested) during commercial grain crop harvest (Walsh and Powles 2007). **4 - Communication:**. AHRI is committed to delivering AHRI's and other relevant research to the Australian broadacre cropping industry in an engaging manner, promoting greater awareness of herbicide resistance and educating industry stakeholders on strategies to increase crop yields and sustain herbicides. Tools to communicate AHRI messages include delivery of website, online courses, live webinars, face-to-face presentations, social media and targeted events.
Crop competition for weed management and maintenance of crop yield (TBC)	Project to ascertain best bet combinations of cultural and chemical weed control tactics for each agro-ecological sub region. Herbicides remain the primary method of weed control in cereal crops because they are very cost effective, hence why farmers are reluctant to adopt integrated weed management (IWM) until they have a serious herbicide resistance problem. When resistance exists, farmers generally change to other modes of herbicide action (including herbicide-resistant crops); however, when resistance to multiple modes of action exists, farmers are forced to adopt more radical nonchemical or cultural control options. Crop competition is widely accepted as an important tactic for suppressing weed growth and maintaining crop yield. Agronomic choices influence crop competition, including crop species and cultivar, row spacing, crop density and row orientation. All these tactics have been shown to impact on the control of in-crop weeds. For wheat, while cultural factors such as row spacing, seeding rate, row orientation, nutrient placement, time of sowing and swathing/time of

	harvest are known to contribute to effective weed management, these management tactics have not been studied extensively in factorial combinations in different environments to demonstrate their relative contributions in a farming system. While significant effort has been focused on competitive agronomy in wheat and other cereals, much less effort has gone into crops such as canola. To advance this research, it is expected that more data will be needed on existing genetic variability of competitive ability in canola x agronomic region x agronomic practice. Using a limited number of diverse canola genotypes validation data could be collected on the existing genetic variability of competitive ability x agronomic region x agronomic practice. Adopting a holistic systems approach should deliver more practical information to growers on likely outcomes of specific agronomic IWM strategies. Growers can then make informed investment decisions.
Surveillance of herbicide resistant weeds in Australian grain cropping (UCS00024)	Between this project and UCS00020 all grain regions are being surveyed once every 5 years for HR status of major winter weeds.US00070 is starting on summer weeds and fallows. Glyphosate resistance weeds form fallows is being identified through UWA00171 (AHRI) and UA00158 as well as recorded in ARN0001 (AGSWG). This research will seek to understand the incidence of herbicide resistance across the cropping region of Australia. This will occur through surveys in which randomly selected cropping paddocks will be visited and seed of common grass or broadleaf weeds collected. Grass weed species will include annual ryegrass, wild oats, brome grass and barley grass. Broadleaf weeds will include wild radish, Indian hedge mustard, wild turnip, fleabane and sowthistle. Other weeds present at high frequencies will also be collected. The weeds collected in the three regions (Northern, Western and Southern) may vary between regions due to differences in cropping programs, climatic conditions and weed diversity. These weeds will then be screened for resistance to a wide range of herbicides commonly used for their control. Southern region starts in 2018.
Validation of the persistence of common residual herbicides in LRZ (DAS00162-B)	There is a need to improve our understanding of how the common herbicides being used in the low rainfall zone persist under current farming systems (which are dominated by stubble retention and no-till crop establishment) and to develop techniques to monitor and manage their presence. There is widespread and rapid adoption of Clearfield crops (wheat, barley and canola) in the low rainfall zone. This has introduced imi chemistry into low rainfall environments where they have been largely absent prior to the development of Clearfield options. Another development which has increased the frequency and diversity of herbicide usage has been increasing emphasis on, and diligence in implementing, weed control over summer to preserve stored water for the following crop. Most low rainfall farmers are now keeping their cropping paddocks free of weeds over summer and this is largely being achieved with herbicides. Farmers and advisers are starting to note production issues in some crops, especially during the emergence and establishment phase, which are suspected to be due to herbicide residues. Managing plant back intervals and herbicide residues are problematic in low rainfall systems for many reasons. Intermediate Outcomes: • High risk situations for residues from the common herbicides identified and communicated to growers and advisers in the low rainfall zone • Low rainfall farmers and advisers have access to sensitivities of common crop and pasture species to glyphosate and group I residues and the impact of varying rainfall amounts on that risk. Long term outcome: Productive farming systems in which herbicides used for effective weed control over summer do not cause production issues for subsequent rotation options.
Stubble Initiative – BCG (BDW00024) – Milestone 19	Additional TWO grass (rye and brome) control trials will be undertaken in each region to demonstrate reactive strategies. The trials are to compare pre-emergent control strategies in different seeding systems (knife and disc) on different row spacings. FIVE workshops will be undertaken to demonstrate herbicide application techniques (nozzle selection, water rate and weed growth stage) in stubble retained systems.
Stubble Initiative –	Milestone 14 – A review summarising existing data for efficacy of practices to control ryegrass,

Component No. 1 – Research – CSIRO – various milestones	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.
Emerging weeds (Seed-bank biology of emerging weeds) – UA00156	The project will address current knowledge gaps in the behaviour of weed seedbanks of emerging weeds in the grains industry. Such information is required for developing short to medium term weed control strategies for different weeds. Weed populations that have evolved mechanisms for increased seedbank persistence will require multi-year control strategies. Any weak links in weed control in the rotations could lead to rapid increase in weed seedbanks but this rate will vary depending on the weed species and genetic variability within a weed species. The project will increase awareness of weed seedbank behaviour of emerging weed species and how this information can be used to improve weed management via fact sheets, GRDC Updates and field days for growers and advisors in northern, southern and western regions. The research undertaken in this project will seek to understand the behaviour of at least 10 selected emerging weed species from the northern, southern and western regions (including barley and brome). Research will investigate seed dormancy, seedbank persistence, seedbank build-up rates and the competitive ability of these weed species in crops. This study will also determine the rate of seed dispersal after maturity, which will indicate the likely effectiveness of weed control methods as seed capture at harvest or the use of weed seed destructor.
New uses for existing chemistry - UQ00080	The overall objective of the project is to identify new uses for existing registered pre- and post-emergent herbicides for the site-specific management of feathertop Rhodes grass (FTR), awnless barnyard grass (ABYG), fleabane, sowthistle, brome grass, barley grass, and wild radish present in crop and fallow situations.
Weed management in the southern region mixed farming systems – strategies to combat herbicide resistance – UCS00020	This project will examine both crop rotations and chemical and cultural practices to determine longer-term impacts on weed management and efficacy of current practices. Research has been performed on management strategies for annual ryegrass, brome grass, fleabane, and witchgrass spp. in particular, using both chemical and non-chemical strategies.
Mechanisms, evolution and inheritance of resistance - UA00158	The objective of this project is to develop new understanding of the mechanisms, inheritance and evolutionary dynamics of resistance to key herbicides in Australian agriculture. The project will concentrate on understanding glyphosate resistance in brome grass, barnyard grass, sow thistle, windmill grass, fleabane and feathertop Rhodes grass; 2,4-D and diflufenican resistance in Indian hedge mustard; 2,4-D resistance in common sowthistle; clethodim resistance in annual ryegrass; and resistance to the pre-emergent herbicides trifluralin, propyzamide, triallate and prosulfocarb in annual ryegrass.

Issue No. 24 - The lack of low cost open pollinated canola varieties is contributing to the reduction in canola area in the low rainfall zone

Identified traits of new and improved canola varieties for the high rainfall zone include –

- Physiology and phenology
  - range of flowering times
  - early vigour
  - lodging resistance
  - yield
  - specialty oils
  - shattering resistance
  - pollen abortion resistance
- Herbicide tolerance
  - Imi + triazine Herbicide tolerance
  - Imi herbicide tolerance
  - Triazine + glyphosate herbicide tolerance
  - Glyphosate + imi Herbicide tolerance
  - Imi + triazine + glyphosate Herbicide tolerance
  - Clethodim tolerance
- Pest resistance
  - RLEM, Lucerne Flea, Green peach aphid, false wireworm, slaters and slugs
  - Diamondback moth, Native budworm
- Disease resistance
  - Blackleg
  - viruses – Beet Western Yellow Virus and Turnip Mosaic Virus
  - abiotic stresses
  - heat, frost, drought
- Sub- soil constraints
  - acidity, salinity and sodicity

GRDC investments addressing this issue

National Brassica Germplasm Improvement Program	The National Brassica Germplasm Improvement Program (NBGIP) has defined priority traits for germplasm enhancement to support and improve the Australian canola industry. These are alternative sources of blackleg resistance, drought and heat tolerance, pod shatter resistance and improved oil content and stability. This project provides Australian Canola breeders with new or improved sources of open-pollinated germplasm, an improved understanding of the genetics underlying these key priority traits together with appropriate breeding tools. Research undertaken within the NBGIP will focus on: Blackleg The genetics underlying blackleg resistance, especially for adult plant resistance, are poorly understood. Moreover, no new sources of seedling resistance are available for breeding use. As the pathogen has the ability to overcome resistance in canola varieties, several seedling resistance genes present in the current Australian canola varieties have become ineffective in providing resistance under field conditions. Therefore, new sources of resistance are constantly required. NBGIP will identify new sources of resistance in diverse canola germplasm accessed from overseas as well as in relatives of canola such as turnips and cabbages. Quantitative (adult plant) resistance conferred by a number of minor genes is likely to be a more sustainable approach to maintaining resistance and prolonging the effectiveness of major genes. Therefore, this project will optimise methods to readily screen for the presence of minor genes. Drought and Heat These are the major environmental stresses limiting canola plant growth and productivity in Australia. Extended period of drought and high temperatures especially at flowering and pod-filling stages can lead to significant crop losses. The NBGIP project will investigate genetic variation

	for various component traits implicated in drought and heat tolerance such as grain yield, above-ground biomass production, early seedling vigour, pollen abortion and physiological traits. Shattering Despite extensive breeding by canola breeding programs, high levels of pod shattering still occur and significantly impact grower profitability. This project will evaluate diverse canola germplasm accessed from overseas including turnips and Ethiopian mustard and develop genetic solutions to reduce yield losses due to pod shattering. Oil yield Canola has the potential to deliver farming systems benefits in the Northern region (as a break crop for controlling take-all, crown rot and nematodes). However, it is not widely grown since many growers regularly have problems meeting minimum oil content (42%) with currently available cultivars. NBGIP will evaluate diverse germplasm accessed from Germany and elite varieties from Australia for improved oil content and stability attributes for target environments across Northern NSW.

Issue No. 31 - Rhizoctonia – economics of fungicides (seed dressings and in-furrow application)

Rhizoctonia a major disease of the low rainfall zones as the fungus is adapted to dry conditions and low-fertility sands. This disease can cause significant yield losses of up to 50% within affected paddocks. Past research has been conducted by SARDI to evaluate the effects of a range of fungicides and delivery systems. Growers and advisors have identified the need for a decision-support tool to assess the likely return on investment from the fungicide treatments for a range of situations e.g. risk, paddock history, potential yield etc.

GRDC investments addressing this issue -

Fungicide control of rhizoctonia – Part A (DAS00125)	This is a collaborative project involving SARDI and UniSA with co-investment by GRDC and SAGIT to deliver new technologies and knowledge faster to growers on where and how to band fungicides in soil relative to the seed to minimise yield losses caused by Rhizoctonia. To hasten development, collaborative links have been established with the related projects led by CSIRO and in WA by DAFWA. Research outputs with will be delivered as a stewardship management package on the fungicide label as well as through field days, GRDC updates etc. Incorporating appropriate delivery and machinery technologies in new seeding equipment will be encouraged by keeping machinery manufacturers and suppliers informed of the research findings. Rhizoctonia barepatch, caused by Rhizoctonia solani AG8, is an important disease of cereals in southern Australia. If the project is successful, then 5 years after completion of this project, it is anticipated 20% of growers will have adopted use of the new fungicides to reduce combined yield losses in wheat and barley by $5 million pa in the southern region and $2. 7 million pa in the western region. The greatest benefits are expected to be achieved by growers using minimum till seeding systems in the low to medium rainfall districts.
Fungicide control of rhizoctonia – Part B (DAS00123)	Syngenta Uniform® registration
Fungicide control of rhizoctonia – Part B (DAS00122)	Bayer EverGol® Prime registration
Strategies to provide resistance to the economically important fungal pathogen *Rhizoctonia solani*	The current project builds upon and extends these exciting advances by generating and analysing the pathogen resistance of transgenic wheat and Arabidopsis lines with altered expression of genes identified in the previous project. In order to appropriately drive the expression of the transgenes, the project will also identify and characterise plant promoters that provide pathogen resistance without affecting other aspects of development and yield in crops. In addition, the

(UWA00154)	project explores the genetic differences between related *R. solani* AG8 isolates that we have identified, that have contrasting pathogenicity on Arabidopsis that a) opens up possibilities to identify key pathogenicity determinants in *R. solani* and b) the opportunity to test strategies to counteract these to provide enhanced resistance to *R solani*. The applicability of some of this knowledge to canola will also be investigated and implemented where possible.
Innovative approaches to resistance to necrotrophic pathogens and sap-sucking insect pests (UWA00145)	This project identified regulatory genes able to enhance resistance to Rhizoctonia solani in medicago or wheat. Genomic sequences for Rhizoctonia solani (cereal & legume pathogens) were generated and three pathogenicity proteins were identified, which allow for the selection of loss-of-sensitivity loci in legumes and cereals. Additionally, Fusarium oxysporum f.sp. medicaginis was sequenced, which has assisted ICRISAT to sequence the pathogen causing Fusarium wilt of chickpea. Conserved effectors from legume infecting F. oxysporum isolates were also found which could enable pre-emptive breeding of legumes against biosecurity risks. Regulatory switches and genes that can help enhance resistance to multiple aphid species were identified.
Continuation of fungicide control of rhizoctonia (DAS00125)	This project studied liquid streaming fungicides to reduce yield losses caused by Rhizoctonia in cereals and informed DAS00122 and DAS00123 both of which were funded to fast track label registrations to liquid stream EverGol Prime® and Uniform®. Dual streaming Uniform® on the soil surface and 3 to 4 cm below the seed was the best treatment and its yield responses were correlated with growing season rainfall at all but 2 sites; a single stream on the soil surface was the next best treatment. Dual banding worked best with knife point and triple disc systems that disturb soil 3 to 4 cm below the seed. Barley hosts more Rhizoctonia than wheat, and variety differences were also detected.