GRDC INVESTMENTS ADDRESS LOW RAINFALL RCSN – June 2017

Issue No. 1 - The loss of glyphosate as a major tool through either regulation or resistant weed species would significantly impact on the profitability and sustainability of farming systems in low rainfall zone.

Our farming systems are heavily reliant of the use of Glyphosate, both as a crop establishment knockdown and for fallow weed control, pasture topping and crop topping of canola, feed barley and sometimes wheat. The loss of this chemical would substantially impact the farming systems in LR areas. While the withdrawal of regulatory support is considered unlikely, loss of efficacy, through increased resistance poses a significant threat. It raises the question of whether it is possible to farm without glyphosate and what techniques would be required. The pressure on glyphosate in the EU was behind the question about ongoing regulatory support.

GRDC investments addressing this issue

GRDC Australian Glyphosate Sustainability Working Group (ARN0001)	Produce the latest information on the status of non-selective herbicide resistance and effective management strategies relevant to their farming systems through a nationally coordinated extension program that includes a specific web site, media releases and extension materials. Integrated weed management training programs will be modified to incorporate the latest developments. A consistent message on the management of glyphosate, paraquat and Group I resistance is extended across Australia. Web site - http://www.glyphosateresistance.org.au Facebook - https://www.facebook.com/Australian-Glyphosate-Sustainability-Working

GRDC – Bayer Crop Science Herbicide Innovation Partnership (HIP00001)	Investment in herbicide discovery. Increasing capacity of Bayer the leading cereal herbicide multinational. Australia lifted to priority 1 status in preliminary screening (equal with EU, USA and Sth America) with 10 Australian weeds in primary screening and primary field screening of molecules occurring in Australia
Australian Herbicide Resistance Initiative (AHRI) – Phase V (UWA00171)	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 (UWA001724)	WeedSmart is established by industry to ensure herbicide options are available for future generations. WeedSmart provides a consistent, single voice for the herbicide industry, linking stakeholders to world renowned herbicide resistance and agronomic research. WeedSmart Phase 3 builds on the strong and effective brand established in Phases 1 and 2 by continuing to work with growers and industry to increase awareness and to provide solutions to keep herbicides working. The WeedSmart campaign ensures that the latest information and practical solutions reach grain growers as quickly as possible. WeedSmart continues to promote practice change on farm by providing growers and advisers with well researched management strategies to curb the impact of resistance and, therefore, increase the sustainability of available chemicals.
Benchmarking and managing soil herbicide residues for improved crop production (DAN00180)	To benchmark the risk of soilborne herbicide residues to crop production, including indirect effects on soil function and direct plant-back risks. To develop models and monitoring tools to assist farmers and agronomists in managing herbicide residues in soils. Anecdotal evidence also suggests that plant-back damage in rotational crops due to herbicide residues is a growing concern amongst growers, but the scale and cost to the Australian Grains industry remains unknown. This project will benchmark level of herbicide residues in cropping soils and generate new knowledge about the fate, behaviour and risk of herbicides to productivity. This will enable the Australian grains industry to better understand the risks and implement changes in management for more productive and resilient farming systems. A review of over 340 peer-reviewed articles found that there is little evidence for consistent, long-term impacts to soil (microbially mediated) functions caused by herbicides when used at registered label rates. Some site-specific exceptions include the interaction of sulfonylurea herbicides with certain pathogens (e.g. Rhizoctonia) on alkaline soils to increase disease risks and inhibit N-cycling processes. Controlled laboratory experiments screened the impacts of 6 different herbicides on soil enzyme activities and N-cycling in 5 different soil types and confirmed that effects are minimal at up to 5 times label rate application. Metsulfuron-methyl had significant but minor impacts (<25% of control level) on nitrification in 3 of the 5 soils tested (impact on 2 alkaline soils and 1 low OM soil). Two nationwide field surveys across in 2015 and 2016 determined baseline levels of herbicide residues in Australian grain growing soils prior to sowing. The dominant residues in both surveys (in terms of detection frequency and residue load) were the herbicide glyphosate and its breakdown product AMPA, plus the herbicides trifluralin and diflufenican. Relatively high levels of triasulfuron and diuron were also found in some regions. Plant bioassays have been conducted to determine the risk of these herbicide residues on crop growth and symbiotic associations (rhizobia in legumes for biological N2-fixation). A new model to predict herbicide persistence in soil has been developed and validated in conjunction with a rapid, inexpensive Quicktest™ to quantify atrazine residues.
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, Sowthistle, 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.
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 sowthistle/milkthistle, 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.
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.

Issue No. 2 - As the global trend for pesticide regulation based on hazard rather than risk continues, deregistration of affordable active ingredients will cause an increase in pesticide costs and erode profit margins.

In the low rainfall zone, pest and weed management is often based on the use of low cost generic products. Several of these are under the threat or are about to be de-registered. The application of the precautionary principle (hazard based assessment) may restrict access to commonly used cost-effective chemicals with the need then to use more expensive options. There is the need to advocate for the protection of farmer's interests in any attempt to deregister active ingredients.

GRDC investments addressing this issue -

Not within the GRDC mandate as this is a policy matter dealt with through both the APMVA and legislation which is managed by the Dept. of Agriculture and Water. Policy issues need to be through grain grower representative groups such as GPA and GGL.

GRDC may provide scientific comments on APMVA documents and does so where there are documents for public comment such as registration public release summaries (PRS), chemical review and trade advice notices (TANs).

GRDC invests with the agrochemical industry where a) there is market failure and b) the investment will address data deficiencies identified in any review. E.g. paraquat working with Syngenta , omethoate and dimethoate – no investment as companies are addressing Arista and FMC respectively.

Issue No.3 - Increased model skill in seasonal forecasts provided from March to May and better forecast utilisation by growers and advisers presents an opportunity to improve decision-making management risk more effectively.

In low rainfall areas, there can be considerable benefits in adopting alternative seeding plans depending on where the season is heading. It would be highly advantageous to have access to more skilful seasonal outlook forecasts at the time of planting. Coupled with this is the need for improved methodology for utilising forecasts of varying skills in effective decision making.

GRDC investments addressing this issue -

Impacts of climate on low rainfall and marginal areas (CSA00053)	The project gathered information relevant to all GRDC's agro-ecological zones focussing on the Low Rainfall Zone (< 250mm). It undertook a series of reviews around farm business structure and climate risk, methods for effective identification of resilient genetic traits from existing trials, and climate prediction services. A reviews and survey revealed that the most significant barriers to use of seasonal cropping forecasts were: • perceived lack of local or regional relevance; • perceived lack of sufficient lead time; • perceived lack of skill/accuracy during periods when critical farm level decisions and period of time during which the SCF has perceived skill; • context relevant knowledge products; and • perceived lack of application to understanding how SCF's translate to measurable improvements in farm profitability.
Assessing and managing heat stress in cereals (MCV00006)	As part of the large Managing Climate Variability Initiative (GRDC, MLA, BoM), this project investigated the damage to wheat yield caused by hot spring days, the likelihood of these hot days and strategies to manage the risk. When the likelihood of a hot day is considered in the context of flowering time, flowering in October and early November in some of the high rainfall regions have similar or higher risks of a hot day than low rainfall regions flowering in September. Through discussions with grain growers and agronomists, a spread-sheet and interactive workshop has been developed which explores the trade-offs between the heat and frost risk. The most likely use of the risk management information is tactically in a season that the break is late (hence heat stress dominates over frost risk) and a grain grower is weighing up the risks on whether it is worth sowing marginal paddocks.
Improving forecast accuracy, especially with improved Indian Ocean Initialisation (MCV00008)	Overview Sea surface temperature (SST) variations in the tropical Indian Ocean are a prominent source of climate variability for Western Australia through to south-eastern Australia. Much of the climate anomalies that develop over south-eastern Australia during El Nino Southern Oscillation (ENSO) events are a result of the co-variance with SST in the Indian Ocean. The forecast skill of tropical Indian Ocean SST with the POAMA1.5 and POAMA2 seasonal forecast systems is much less than for that in the Pacific Ocean. The main purpose of this project was to investigate the reasons for the lower skill in the Indian Ocean, to what extent this has improved in POAMA-2 which utilises a new ocean data assimilation scheme and to what extent further improvements in the ocean initialisation can lead to increased skill. During the project there were two upgrades to the operational version of POAMA. POAMA- 2P replaced POAMA-1.5 as the Bureau's seasonal prediction system. POAMA-2P included the new ocean data assimilation system called PEODAS. Evaluation of the impact of PEODAS was carried out as part of this project. There was also a second upgrade to POAMA-2M, a version more suitable for multi-week prediction. POAMA-2M included some enhancements developed as part of the MCV-Multiweek project. In May 2013 the Bureau decided to start using POAMA forecasts for its official seasonal climate outlook, the first time that dynamical based forecasts have been used at the Bureau for regional temperature and rainfall. This is a major step for the Bureau as it shifts from basing its climate outlooks on statistical models to basing the outlooks on a dynamical model, POAMA. The main outputs of this project were threefold: (a) Increased understanding of the use of ocean observations by the POAMA model, the performance of the assimilation technique, and the impact of the systems on the forecast performance, including benchmarking against other international systems (b) Development and evaluation of improvements to the initialisation strategy, and recommendations for which should be included in the next version of POAMA (c) Science papers and research reports that document the project discoveries
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.

Issue No.4 - The risk (either perceived or real) of herbicide residues accumulating in sandy soils in low rainfall environments is reducing returns.

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

GRDC investments addressing this issue

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

Management of residual herbicides in broadacre cropping (THA00001)	Summary of past work and gap analysis for southern region; Extension to increase awareness: • Residual herbicide behaviour in soils • Residual herbicide breakdown mechanisms • Effect of seasonal conditions on persistence • Likely high risk situations • Farming systems interactions • Collated plant back summaries for residual herbicides • Risk assessment matrices to enable anticipation of potential problems as farming systems evolve. Gaps: • Sandy soils and impact on residual herbicide persistence; • IMI- impact of residues on conventional crop yields compared to tolerant varieties across a range of soil types; • IMI-retrospective analysis of Intervix plant back trial data held with BASF and Nufarm to refine label requirements; • IMI-promotion of strategic use of IT technology; • Clopyralid (Lontrel) behaviour in soils in the context of modern farming systems; • Lentil variety development- dicamba tolerance and improved IMI tolerance; • Alternate herbicide use options to Clopyralid and 24 D amine) Recommendations • Package up simple messages for farmers and more detailed background information for advisors addressing the gaps • Annual production of plant back summaries with company updates or amendments. • Targeted field trials for specific regional issues as above . • Herbicide plant back working group to advise on the content and format for message delivery for a response package and oversea the outcomes of field work. • The use of extension methods that cater to the varied learning preferences of farmers and advisors including but not limited concise fact sheets, on-line resources and field based training exercises. Comments: GRDC working with companies to address some of these gaps. Need to address liability.

Issue 5 - Limited knowledge, skills and experience of growers and advisers new to pulse growing increases production risk of pulses in the low rainfall zone.

The expansion of lentils and chickpeas into new areas and further into the low rainfall zone in the past 5 years has boosted profitability. Pulses are complex to manage and poorly managed crops pose a risk to profitability of inexperienced growers. Field peas and lupin areas have also expanded.

There is a lot of interest in growing pulses in low rainfall areas but knowledge, skills and experience is limiting the ability of growers to successfully grow profitable pulse crops in the low rainfall zone. There is also the need to refine pulse management techniques from higher rainfall areas to make them more relevant for quicker finishing and less reliable rainfall districts. The interest in pulses is leading to increased plantings so growers are intending to plant them while lacking knowledge, skills and experience, which is likely to result in reduced returns.

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

Facilitating increased on-farm adoption of broadleaf	Research was undertaken in partnership with 7 grower groups across the southern region to determine whether production risks associated with difficult to manage grass weeds, or

species in crop sequences to improve grain production and profitability (aka 'crop sequencing' project) (CSP00146)	management of soil N, in cereal-based systems could be profitably addressed using legumes or brassicas break crops. Trials showed that: (1) the profitability of break crops was either similar to or greater than wheat, (2) sequences including at least one break crop were more productive and profitable than continuous wheat when using best management practices, (3) the cost of controlling herbicide-resistant grass weeds in continuous wheat systems was more expensive and less effective than alternative options available in break crops, and (4) rates of N fertiliser after legumes can be reduced to meet target grain yield and quality. The expected economic outcome includes improvements in the stability of grain production and system profitability, reduced costs and risk of production. The increased diversity of crop species grown also causes improved water and nutrient use by more vigorous cereal crops grown after break crops resulting in a reduced risk of deep drainage, nitrate leaching and greenhouse gas emissions, and lowered rates of soil acidification and salinization.
Understanding the implications of new traits on adaptation, crop physiology and management of pulses in the southern region (DAV00151)	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 and France 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. Variety specific agronomy packages will also be developed. 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.
Optimising nitrogen fixation of grain legumes – Southern Region (DAS00128)	This project is improving the amount of fixed nitrogen (N) by pulse legumes and their contribution to cropping systems in South Australia and Victoria. It is: 1) Developing N fixation indices that rank potential N fixation capacity of field pea cultivars. 2) Identifying opportunities to improve nodulation, N fixation and inoculant use, 3) Evaluating new inoculants to improve nitrogen fixation by pea, bean and vetch, 4) Improving the rhizobial genebank available for N fixation research. Data has shown large differences in the amount of biomass and fixed N produced by different pea genotypes. Data from field trials has been used to develop a symbiotic rating system for field pea and to provide improved inoculation guidelines for growers. The project has improved our understanding of nodulation thresholds, rotational benefits and inoculation response in field pea.

Profitable crop sequencing in the low rainfall areas of South Eastern Australia (DAS00119)	Trial and demonstration activities showed that wheat preceded by a two year break yielded better than continuous wheat, by at least 0.5 and to more than 1 t/ha in the first year following the break and by up to 0.5 t/ha in the second subsequent crop. Any break combination which substantially reduced the major constraints to wheat production, resulted in large yields benefits - these constraints were mostly grassy weeds but rhizoctonia and low N fertility was also factors. Gross margin comparisons show that 2 year breaks can be as profitable, and sometimes even better, over 5 years than continuous wheat, providing at least one of the break years produced a reasonable profit. One year breaks resulted in improved wheat production but grassy weed levels built again quickly. Continuous wheat became increasingly expensive to manage as low N fertility and building grass pressure demanded higher inputs. Microbial health was highest in those sequences which had a vigorous, legume-dominant pasture and poorest where a fallow had been included. Two years of diverse cropping options was not sufficient to change the frequency of N-fixing or nitrifying genes in the soil bacteria, except for fallows usually causing a decline. Results from this project show the benefit from the measurement of microbial biomass, N mineralization potential and nitrifying organism populations for better understanding of rotation effects in different soil environments. APSIM simulations based on data from four of the core sites estimated that the yield of field peas and canola would be 47-73% and 49-67%, respectively, of wheat under the same conditions. This relationship did not hold in high yielding seasons, probably because APSIM poorly simulates the impact of heat and frost on grain yields, especially for break crops. Risk analysis of field pea and canola performances developed through APSIM showed that while gross margins for these two break crops are favourable relative to wheat, they are more risky and more variable options.
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.
Profitable crop sequencing in the low rainfall areas of South Eastern Australia (DAS00119)	The conclusion of this project will result in more reliable and more productive low rainfall farming systems through the increased use of less risky broad leaved break phases. These breaks will increase subsequent cereal production, improve the economic impact of the break in those years of production and diversify farm incomes.

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. 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?

Issue 6 - Opportunities to improve the integration and management of livestock into the farming system with site specific grazing is impeded by technology cost and state regulation.

Access to virtual fencing could provide substantial advantages for grazing the large areas common in low rainfall areas. Technology is currently uneconomic but it is not possible to do local research given that virtual fencing is currently illegal in SA and Vic. It would also help with managing variable soil types within large paddocks i.e. prevent over grazing of sand hills and the subsequent increase in erosion risk.

GRDC investments addressing this issue

No GRDC investment addressing this issue which relates to legislative change.

Issue 7 - R,D & E capacity in the low rainfall zone is diminished by retraction of public investment in infrastructure and human resources and the exit of experienced professionals.

There has been a steady decline in the R, D and E capacity across agriculture, particularly in LR areas which may not be highly attractive areas of work and careers against other alternatives. Included is the need for a mentoring program to support staff at remote research facilities.

GRDC investments addressing this issue

GRDC-SARDI Bilateral Agreement (DAS00165-169)	As part of the SARDI/GRDC bilateral agreement, the SA government has funded the upgrade of research facilities at Loxton ($7.5M – offices and laboratories, conference and meeting facilities) and Clare ($4M – laboratory, workshop, shade house and offices). The bilateral program 5 is specifically building regional capacity in delivering agronomic R&D, through the appointment agronomists working at Minnipa, Port Lincoln, Clare, Waite Loxton and Struan, along with support for local technical staff.
Improving practices and adoption through strengthening D&E capability and delivery in the South Region – Regional Research Agronomists (DAV00143) GRDC-DEDJTR Bilateral Agreement	Program 7 under the SARDI/DEDJTR bilateral is specifically building regional capacity for delivering R&D in Victoria. This program has supported three agronomists with science qualifications able to implement planned R&D work. In addition, three cohorts of young science/agriculture post-graduates (each cohort consisting of three graduates) have been recruited and trained in agronomy D&E for a period of 18 months, spending 6 months each in Agriculture Victoria, a grower group, and an agribusiness. The program is widely recognised as successful, with trainees rapidly finding employment, and hence, there is advanced plans to expand this program. Additional positions in the Victorian Mallee will provide coverage across the low rainfall districts.

Issue No. 8 - Opportunities to improve profit are missed as new practices are not adopted due to a lack of grower trust in small plot results.

Growers tend to be suspicious of the results from small scale trials and would like to see results on a larger paddock scale before adopting the technologies.

GRDC investments addressing this issue

GRDC Stubble Initiative (various projects)	The Maintaining Profitable Farming Systems with Retained Stubble Initiative involves grower groups in Victoria, South Australia, southern and central New South Wales and Tasmania collaborating with research organisations and agribusiness to explore and address issues for growers that impact the profitability of cropping systems with stubble. The grower groups have extensively used large-scale paddock demonstrations to investigate a broad range of issues (including pests, diseases, weeds, nutrition and the physical aspects of sowing and establishing crops in heavy residue) and fine-tune management practices based on the large-scale experience.

Issue No. 9 - 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).
Over-dependence on agrichemicals (CWF00020)	The issue of herbicide resistance and alternative methods of weed control has been identified as a common theme across all farming systems groups' regions within the Southern LRZ. R&D activities are addressing the following projects issues: row spacing, crop competition, cover crops & pastures, and weed seed control via harvest activities. Through the proposed project activities reliance upon farm herbicide inputs and their associated costs and risks will be reduced. Various trials have been conducted in partnership with various grower groups: sowing direction and row spacing (BCG); cover crop and termination methods (MSF), row spacing x sowing rate and row direction x row spacing (EPARF); sowing rate and crop competition with barley grass (UNFS); narrow windrow burning and chaff carts (CWFS).

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 both 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.
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) Smarter grazing of crops and stubbles to optimise business and production risk and increase profit - 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) Better manage crop and pastures (within) a rotation to improve crop and livestock production - 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) 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 (NRS00009)	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. 10 - The strong preference growers demonstrate for peer to peer learning via digital communication (Twitter) is an opportunity for effective extension to builds skills and capacity and practice change.

This issue recognises the current and developing importance of social media in agricultural extension and seeks to explore mechanisms by which this can be further enhanced.

eXtensionAUS – trial (EXF00001)	eXtensionAUS is a national pilot project focused on testing the eXtension model from the USA (www.extension.org) for the Australian grains industry. It is a nationally coordinated extension system can ensure timely access to credible research from across Australia. Working as a community eXtensionAUS can use a proven model to support the collaboration of experts to provide information faster, in more accessible formats, to more people, and provide opportunities for two-way conversations for the Australian grains industry. Pilot participants to date have valued easy access to technical information, being able to build their professional networks and learning to work in new ways using online tools. The Twitter accounts @AusCropDiseases and @AuCropNutrition and the website www.extensionaus.com.au have been particularly popular eXtensionAUS products to date. 'Ask an Expert' allows you to get your questions answered by nationally coordinated teams of expert.