GRDC INVESTMENTS ADDRESS HIGH RAINFALL RCSN – June 2017

Issue No. 1 - Identify and develop high value grain crops to complement existing common crops

Most traditional crops grown in the HRZ are bulk commodities which compete with other high volume suppliers around the world. The introduction of new high value grain crops would have a positive impact and be applicable to most growers across the HRZ. The direct benefit would be increased profit, with wider gains through diversification of rotations potentially enabling alternative options for weed control, nitrogen accumulation, disease break, soil amelioration and water use. Depending on the crop, new beyond farm gate industries may emerge in handling and processing.

GRDC investments addressing this issue

Hyperyielding cereals - a feedgrain initiative (FAR00003)	Whilst not focussed on new grain crops for the HRZ, this project seeks to improve grower profit through step change improvements in yield of cereals grown in the HRZ. The objective of the project is the delivery of higher yields of quality feed grains in HRZ through genetic improvement, management and recognition of quality. Specific outputs are: 1. Engagement between breeders, researchers, growers and advisers to evaluate and better manage new feed wheat and barley cultivars with the target of increasing average red feed wheat yields from 4.4 t/ha to 7t/ha by 2020. 2. Delivery of commercial wheat crops yielding 14t/ha by 2020. Through engaging and collaborating with the dairy industry the project also seeks to identify and endorse the value of metabolisable and digestible energy in feed grain cereals and: 1. Create an independent testing and reference system whereby high yielding cereals can be reliably described in terms of energy content and value to the end user (particularly dairy industry). 2. Create a positive environment based on trading feed cultivars with quality attributes for better milk solid production in order to create the stimulus for further investment in improved variety development.
Collection, phenotyping and exploitation of wild Cicer genetic resources for chickpea	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

improvement (CSP00185)	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.
Waterlogging and Acid soil screening of Pulses (UT00021)	To assess a diverse range of grain legume germplasm (lentil, faba bean and pea) for tolerance to waterlogging and soil acidity.
N fixing break-crops and pastures for high rainfall zone acid soils (DAN00191)	There is a lack of reliable nitrogen fixing break-crop options for low pH soils in the southern high rainfall zone (HRZ). Consequently a pressing need to develop reliable legume crop and forage rotation option exists The three key issues driving this project are : 1) To reduce reliance on fertiliser nitrogen; 2) To improve management of herbicide resistance in the important weeds of cropping systems; and 3) To improve integration of livestock into the local farming systems.
Southern Pulse Agronomy (DAV00150)	Building on previous projects through targeted research and development activities, this project will continue to contribute to the understanding of pulse growth and performance under changing environmental and management conditions. This will lead to improved yield and yield stability of pulses, ultimately leading to increased profitability and adoption of new varieties by growers.
The potential of the pearl lupin (Lupinus mutabilis) for southern Australia (UWA00043)	Develop a range of domesticated breeding material with appropriate grain quality and agronomic characteristics that could form the basis of the first pearl lupin cultivar release for Australia. Research data on pearl lupin genotype performance on a range of soil-types, waterlogging, pH and herbicide tolerances, and reaction to the major lupin diseases and pests. Conduct whole grain and kernel proximate analysis on a range of genotypes grown in a range of environments; protein concentrate yields and feed performance data for fish (salmonid - rainbow trout)

Issue No. 2 - Improved assessment tools (site specific and spatially referenced) to better inform tactical N management decisions

Nitrogen (N) management is a key driver of yield and profitability of all non-legume crops in most seasons within the high rainfall zone. Improved technologies and tools to accurately and rapidly measure in-crop N status would enable better in-season tactical N decisions, both between and within crops. It would also enable more intensive and frequent measurement of N which would provide the information required to customise N management. Customised and variable rate N applications would increase N use efficiency, return on investment and profit.

GRDC investments addressing this issue –

Real time evaluation of soil nitrate using ion exchange technology (EPF00002-A) and (UA00165)	This project seeks to better assess N supply to cereal crops and canola in the southern region, based on an improved estimation of mineralisation of soil N and the supply of N from legume crops and pastures. The project will undertake a number of activities that aim to assist and inform advisors and growers in understanding N dynamics in cropping systems to improve N supply to crops.

Tools for rapid, real time measurement of nutrients (CSO00045)	The development of new soil testing methods, which are rapid, cheap, accurate and spatial, is needed for the implementation of sustainable farming practices in the grains industry in Australia. The main objectives are to: • Review currently available proximal soil sensors that may be used in the management of Australian grain-growing soil • Assess the feasibility of commercialising a selected set of sensors—operating alone or as part of an ensemble.
Soil spectroscopy capability (CSO00045)	The Project will examine the performance of field spectrometers for the rapid and inexpensive assessment of key soil properties important in controlling production of grain crops in Australia. The study will focus on the application of the spectrometers as handheld devices, or in applications where the instrumentation can be integrated into current commercial soil sampling equipment (e.g. core drill equipment)
Nitrogen inputs by free living nitrogen fixing bacteria – Grower messages (CSP00191)	This project is mainly to develop user friendly information based on the scientific research outputs from the recently completed project CSP00138. To develop extension messages based on the findings from the project CSP00138 and GRDC Soil Biology Initiative II Theme based projects to identify areas that this is likely to produce agronomically significant amounts of N inputs and to help growers and agronomists incorporate contribution from FL-N fixation in their N management decisions.
More Profit from Crop Nutrition (MPCN) II – Regional soil testing guidelines for the southern region (DAN00168)Proximal Soil Sensing for Profitable and Sustainable Farming (CSA00048)	To better match NPKS fertiliser inputs to crop demand and hence meet the twin goals of maximising economic response to fertiliser yet minimising potential loss of nutrients to the environment.
Updated nutrient response curves in the northern and southern regions (UQ00082)	Review and synthesise the currently available macro-nutrient response curve data to identify and prioritise gaps that will constrain growers and advisors ability to identify likely nutrient limitations and therefore fertilizer responsiveness for key crops in their rotations; Sow trials to further create a critical soil test to determine accurately the nutrient requirement x crop type (What, Barley, Oats, Canola, Legumes)

Issue No.3 - Enhanced accuracy of N management decisions

The key nitrogen management decisions are amounts/rates and timing of applications. A range of N budgeting tools which calculate N fertiliser requirements given N demand based on target yield and protein less N supply from mineralisation. The amount of N supplied through mineralisation is highly variable. Hence, the calculated amount of required N fertiliser can only be considered a "guide". Crop models have not been calibrated for regional conditions in the region which limits the accuracy and reliability of using NVDI information as a tool to estimate N requirements. The development of technologies and tools to measure N rather than rely on estimates of N would increase the accuracy of N management decisions. Improved seasonal forecasts and crop models would also enable growers to adapt tactical N management based on potential yield given seasonal conditions.

GRDC investments addressing this issue -

Real time evaluation of soil nitrate using ion exchange technology (EPF00002-A) and (UA00165)	This project seeks to better assess N supply to cereal crops and canola in the southern region, based on an improved estimation of mineralisation of soil N and the supply of N from legume crops and pastures. The project will undertake a number of activities that aim to assist and inform advisors and growers in understanding N dynamics in cropping systems to improve N supply to crops.

Managing legume and fertiliser nitrogen in the Southern Region (UA00165)	The project will construct and economic model that can evaluate the role of fixed and residue nitrogen in modern farming systems. This tool will help farmers evaluate the profitability or otherwise of growing grain or pasture legumes as commodity prices vary, as fertiliser prices vary and as attitudes to risk change. A new biophysical economic framework that values commodity prices, left over nitrogen and fertiliser prices will be constructed to deliver a tool to farmers that help them evaluate the role legumes can play in their farming system. The calculator will also evaluate risk, as the decision to grow a legume may alter the risk profile for the subsequent cereal crop.
More Profit from Crop Nutrition Initiative – Phase II (MPCN II) Re-assessing the value and use of fixed nitrogen (CSA00037)	The project will construct and economic model that can evaluate the role of fixed and residue nitrogen in modern farming systems. This tool will help farmers evaluate the profitability or otherwise of growing grain or pasture legumes as commodity prices vary, as fertiliser prices vary and as attitudes to risk change A new biophysical economic framework that values commodity prices, left over nitrogen and fertiliser prices will be constructed to deliver a tool to farmers that help them evaluate the role legumes can play in their farming system. The calculator will also evaluate risk, as the decision to grow a legume may alter the risk profile for the subsequent cereal crop.
More Profit from Crop Nutrition Initiative – Phase II (MPCN II) Benchmarking wheat yield against nitrogen use (DAS00147)	To create a robust benchmark for the nitrogen status of current wheat varieties. This will allow growers to better match nitrogen inputs to meet crop demand. We will develop a so called 'nitrogen dilution curve'. This curve shows the minimal concentration of nitrogen in shoots that is required to achieve maximum growth. Crop nitrogen status can then be assessed by dividing the actual nitrogen concentration of the crop at a given biomass, by the critical nitrogen concentration derived from the nitrogen dilution curve at that same biomass. The outcome is a Nitrogen Nutrition Index.
Soil spectroscopy capability (CSO00045)	The Project will examine the performance of field spectrometers for the rapid and inexpensive assessment of key soil properties important in controlling production of grain crops in Australia. The study will focus on the application of the spectrometers as handheld devices, or in applications where the instrumentation can be integrated into current commercial soil sampling equipment (e.g. core drill equipment).
Proximal Soil Sensing for Profitable and Sustainable Farming (CSA00048)	The development of new soil testing methods, which are rapid, cheap, accurate and spatial, is needed for the implementation of sustainable farming practices in the grains industry in Australia. The main objectives are to: • Review currently available proximal soil sensors that may be used in the management of Australian grain-growing soil • Assess the feasibility of commercialising a selected set of sensors—operating alone or as part of an ensemble.
Improving nitrous oxide abatement in higher rainfall cropping systems and developing nitrogen response curves (DAV00125)	The challenge will be to develop practical management strategies so that grain growers can simultaneously reduce excessively high levels of soil mineral nitrogen and labile carbon (which lead to high N2O emissions) following pasture conversion whilst maintaining sufficient N to supply the demand of large yielding grain crops in an environment characterised by high rainfall and/or often water logging. Growers and advisers in the Southern Region will have access to N response curves for representative sites (soils varying in organic matter and N content) and seasons, leading to better predictions of how much fertiliser N growers need to apply to different crops.
Reassessing the value and use of fixed nitrogen (CSA00037)	The project will construct and economic model that can evaluate the role of fixed and residue nitrogen in modern farming systems. This tool will help farmers evaluate the profitability or otherwise of growing grain or pasture legumes as commodity prices vary, as fertiliser prices vary and as attitudes to risk change.
Evaluation of late nitrogen applications to achieve yield potential and increased protein in wheat	This fast track project assessed yield and protein responses of wheat to N rate, time and source in the high rainfall cropping zone of south-eastern Australia. Even in seasons where the finish is good, there is no single strategy to achieve grain protein above 10.5% with a high yield. While early N can establish a platform for high yields, the right

(SFS00025)	combination of source, rate and timing to take advantage of any premiums still relies on a little luck with the conditions that follow application.
Nutrient performance indicators (IPN00003)	There are many ways to define nutrient use efficiency, but a meaningful metric needs to be universal and applicable at a range of scales. At a field or farm scale, it is not possible to assess agronomic efficiency as growers are not likely to have nil fertilizer treatments which are required to make that derivation. The objective of this bench marking project is to dis aggregate fertilizer use data by crop and region to get mean values for each, and then compare these mean values to on-farm nutrient balances taken from a sample of farms across the one of the three GRDC regions.
Strategies to better synchronise nutrient supply and crop demand (UM00023)	2007 project: This project will improve the efficiency of nutrient use by identifying factors affecting spatial and temporal supply of N and P, matching them to crop demand. This knowledge when matched with estimates of the size and dynamics (storage and rates of loss) of soil nutrient pools will be used to develop management guidelines to improve the efficiency of nutrient use in complex farming systems in 3 agro-ecological zones of south-eastern Australia.
Nitrogen and water interactions (DAS00157)	Objective of this investment is to understand the interaction between soil moisture, seasonal forecast and soil nitrogen and its impact on nitrogen fertiliser decision-making.
Understanding how waterlogging affects water and nitrogen use by wheat (DAV00151)	This project will use a combination of field measurements and modelling to: 1. Enhance understanding of the effects of waterlogging on crop growth and water and nitrogen uptake and the consequences for grain yield and quality and 2. Identify management practices that may increase crop production on waterlogging-prone soils.
Optimising nitrogen fixation of grain legumes - southern region (DAS00128)	This project will improve the amount of fixed nitrogen (N) contributed to cropping systems in southern Australia (South Australia & Victoria) from pulse legumes. This project will quantify the symbiotic potential of different pulse cultivars and lines, so N fixation indices can be developed and used by pulse development programs and growers.
Updated nutrient response curves in the northern and southern regions (UQ00082)	Review and synthesise the currently available macro-nutrient response curve data to identify and prioritise gaps that will constrain growers and advisors ability to identify likely nutrient limitations and therefore fertilizer responsiveness for key crops in their rotations; Sow trials to further create a critical soil test to determine accurately the nutrient requirement x crop type (What, Barley, Oats, Canola, Legumes)

Issue No.4 - Improved management packages for multi-herbicide resistant annual ryegrass

Surveys have shown very high levels of herbicide resistance in annual ryegrass (ARG) is widespread across the high rainfall zone. ARG populations in the high rainfall zone have developed resistance to multiple groups of herbicides. The long growing season in the high rainfall zones results in large populations of herbicide resistant ARG which can germinate very late in the season (September to November) after in-crop herbicides have lost their efficacy. The on-going population of ARG reduces yields, limits crop options and less effective and/or increased input costs for weed control which is significantly limiting the profitability of farming systems. Improved management packages which provide season-long control of ARG in the high rainfall zone are required.

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.
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.

Harvest weed seed control for the southern region (SFS00032)	Develop and validate harvest weed seed control techniques for the higher rainfall and irrigation areas of the southern grain cropping region of Australia. The project Harvest weed seed control (HWSC) for the Southern high rainfall zone was implemented to evaluate the efficacy and reliability of HWSC practices in that region. Seven small plot trials have been implemented over 2015 and 2016 with the main focus being on annual ryegrass (ARG). In 2015 three trials were conducted investigating the impact of varietal phenology, time of sowing (TOS) and harvest height. three wheat varieties, early, mid and late maturity were sown a three different TOS, (early, mid & late). Each treatment was harvested at 15cm high or 30cm high to impersonate HWSC harvest technique (15cm) or the more traditional harvest heights of 30cm. All harvest trash was captured in bags and removed to prevent any ARG weed seed that entered the plot harvester being placed back on to the plots. Weed seed shedding prior to harvest was collected in two trays per plot to determine numbers of weed seeds escaping the HWSC system. In 2016, as a result of no significance of any treatments in 2015 on ARG soil seed bank numbers, trials were sown to one variety at one TOS and harvested at the same height as used in 2015. This would provide large numbers of replications to smooth out impacts of ARG weed density variation. Native populations of ARG across all sites were highly variable as evidenced in 2015. Four on farm trials were also implemented in in 2015 and another 4 on farm demonstrations in 2016. Two were at existing sites from 2015 and two were new sites in 2016.
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.
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.
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. Current Southern surveillance in under UCS00020
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 brome grass 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, brome grass, fleabane, and witch grass 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 brome grass 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.
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.
Technical Workshops - Southern Region - Herbicide Resistance management (ARN00002)	Equip growers and agronomists in the GRDC Southern Region with the skills and knowledge to better manage herbicide resistance and species shift. Farmers will better understand how herbicide resistance and species shift develops and by understanding the critical role of managing weed seedbanks, will implement practices to slow and prevent herbicide resistant weeds being a limitation to their productivity and livelihoods.
Weed management in the southern region mixed farming systems - strategies to combat herbicide resistance (UCS00020)	To perform extensive surveys and trials 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.
Understanding and management of weed resistance to glyphosate (UA00088)	This project will provide recommendations of ways to avoid resistance to glyphosate and the long-term impact of such strategies on risks of glyphosate resistance. This will allow growers to choose strategies that allow continued use of current farming systems that have many resource conservation benefits without greatly increasing the risks of glyphosate resistance.

Issue 5 - Determine practices (rotations) to reduce the high input costs required to grow high yield wheat

Additional inputs to manage weeds, pests, diseases and nutrition are required to grow high yielding wheat crops which increase financial risk. There is the opportunity to reduce inputs, costs and the financial risk whilst optimising yield and maximising profits. Systems/rotation and practices strongly influence weeds, pests, diseases and nutrients and therefore influence inputs that are required to grow high yielding wheat crops. Identifying farming systems and strategies which will reduce costs and optimise wheat yields would enable growers reduce financial risk and increase profits.

GRDC investments addressing this issue

Optimising yield and economic impact of high input cropping systems in the High Rainfall Zone (DAV00141)	Agronomists, growers, breeders and scientists will have the knowledge and tools to reliably increase the profitability of wheat and canola production in the high rainfall zones of the Southern and Western grains regions, including • better understand yield formation in canola - new varieties and targeted management • improve the management of high input systems ▪ quantify the production & economic risks of high input systems ▪ develop best management practice guidelines (tools) for growers
Agronomy to support expansion of feed grain production in Tasmania (FAR00003)	Investment includes the development of variety specific management programs for the best lines, expanded to other high rainfall zone grain zones including the adaptation of best

More Profit from Crop Nutrition Initiative – Phase II (MPCN II) Re-assessing the value and use of fixed nitrogen (CSA00037)	The project will construct and economic model that can evaluate the role of fixed and residue nitrogen in modern farming systems. This tool will help farmers evaluate the profitability or otherwise of growing grain or pasture legumes as commodity prices vary, as fertiliser prices vary and as attitudes to risk change A new biophysical economic framework that values commodity prices, left over nitrogen and fertiliser prices will be constructed to deliver a tool to farmers that help them evaluate the role legumes can play in their farming system. The calculator will also evaluate risk, as the decision to grow a legume may alter the risk profile for the subsequent cereal crop.
N fixing break-crops and pastures for high rainfall zone acid soils (DAN00191)	There is a lack of reliable nitrogen fixing break-crop options for low pH soils in the southern high rainfall zone (HRZ). Consequently a pressing need to develop reliable legume crop and forage rotation option exists The three key issues driving this project are : 1) To reduce reliance on fertiliser nitrogen; 2) To improve management of herbicide resistance in the important weeds of cropping systems; 3) To improve integration of livestock into the local farming systems.
Management of high rainfall cropping to improve water quality and productivity (DAV00059)	This project will provide the scientific foundation for the development of improved high rainfall cropping systems and increase the probability that these systems maximise the economic returns to farmers and environmental returns to the wider community. This will underpin practical guidance on crop location, paddock layout and agronomy provided to growers in the high rainfall zone.
Genotype and management combinations for highly productive cropping systems in the HRZ of southern Australia. (DAV00161)	1. Advice to plant breeders on the characteristics required for high yielding, disease resistant, milling quality wheat and barley varieties in the high rainfall zone. 2. Advice to plant breeders on the characteristics required for high yielding, disease resistant quality pulses and oilseeds suitable for rotations with wheat and barley in the high rainfall zone. 3. A 'model' of crop requirements for the HRZ based on existing agronomic, climate and soil data which will be used to plan treatments, interpret results, define suitable germplasm and provide information to growers to aid in management decisions.

Issue 6 - Methods to reduce reliance on foliar and in furrow fungicides

Description: The reliance, prophylactic and repeated use of a limited number of fungicide groups has increased the risk and rate of development of fungicide resistance. The development and adoption of integrated approaches to disease management are required to reduce the reliance and over-use of fungicides. Genetic resistance is essential to reduce the reliance on fungicides to manage diseases. The development of new varieties which provide improved resistance to a range of important diseases is required. The adoption of non-chemical control strategies which reduce inoculum levels prior to fungicide applications are also critical to reducing selection pressure and fungicide resistance.

GRDC investments addressing this issue

Centre for Crop and Disease Management (CUR00023)	CCDM Program 1 - Project A - Early detection and management strategies for fungal diseases CCDM Program 1 - Project B - Best management practices for fungal disease control CCDM Program 1 - Project C - Economics of disease management and capacity development. CCDM Program 2 - Extension and engagement CCDM Program 3 - Septoria nodorum blotch biology CCDM Program 4 - Tan (yellow) spot CCDM Program 5 - Net form of Net Blotch Functional Genomics CCDM Program 6 - Sclerotinia Stem Rot of Canola and lupins CCDM Program 6 - Ascochyta blight of pulses CCDM Program 8 - Durable Resistance to Powdery Mildew CCDM Program 9 – fungicide resistance

Benchmarking resistance and managing Septoria tritici Blotch and Leaf Rust (FAR00004A)	The research will combine field research on fungicide performance with laboratory testing of the fungal populations pre and post fungicide application in the regions where these diseases are most problematic. It will also give an early warning system across the prevalent regions for detection of resistant mutants following SDHI and strobilurin application.
Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease in New South Wales(DAN00177)	Objectives of this investment – 1. characterisation of the frequency of insensitivity in Septoria tritici blotch populations to azole fungicides, and develop and communicate information to sustain the effectiveness of fungicides against this pathogen; 2. survey of high risk regions; 3. annual monitoring of STB monitor for further evolution of mutations in response to changed fungicide use patterns and determine geographical distribution patterns of phenotype sensitivity groups against key fungicides; 4. phenotype isolates to define sensitivity baselines for STB across a range of fungicide dose rates against a minimum of two registered modes of action; 5. sequence genes known to be implicated with fungicide resistance in STB; 6. measure efficacy of currently registered fungicides and new actives for the treatment of Septoria tritici blotch against known mutations using glasshouse pot assays; 7. deliver up-to-date knowledge on fungicide resistance management strategies and molecular tools for each disease; 8. develop a rapid molecular assay for the known fungicide resistance mutations
Crown Rot Resistance – a range of investments	1. Genetic solution to crown rot in barley (CFF00010) 2. Identification and Utilization of Novel Sources of Resistance to Crown rot and the Root Lesion Nematodes in Adapted Spring and Durum Wheat (CIM00018) 3. Integrated Genetic Solutions to Crown Rot in Wheat (US00075) 4. Managing crop diseases - Improving crown rot resistance in durum (USQ00013)
Rust Resistance – a range of investments	1. ACRCP- CIMMYT delivery of resistant germplasm and surveillance for resistance in Australian cultivars (CIM00017) 2. Triple Rust Resistance Project – ACRCP (CSP00161) 3. ACRCP- Molecular marker program CSIRO/University of Sydney/CIMMYT collaborative project (CSP00164) 4. Advancement of new genes for stem and leaf rust resistance from uncultivated relatives of wheat -continuation (UA00141) 5. Australian Cereal Rust Control Program - Durable genes (US00063) 6. Australian Cereal Rust Control Program - National breeding support (US00064) 7. Accelerating the utilisation and deployment of durable adult plant resistance to leaf rust in barley (US00070) 8. Development of genetic tools for Australian barley crops against leaf rust (US00074)
Nematode Resistance – a range of investments	1. Genetic control of nematode species affecting major crops - Germplasm enhancement for nematode control in cereals and pulses (USQ00019) 2. Assessing collections of wild chickpea relatives for resistance to root-lesion nematodes (USQ00017) 3. Collection, phenotyping and exploitation of wild Cicer genetic resources for chickpea improvement (CSP00185) 4. Genetics of wild germplasm, gene-pool expansion and integrated ASSD approach to enhance adaptive potential in chickpea (CUR00024)
Multiple Resistances - a range of investments	1. Focused Improvement of Durum Wheat Germplasm from CIMMYT for Yield Potential, Drought and Biotic Constraints (CIM00020) 2. Reverse genetics for the development of wheat cultivars with improved resistance to necrotrophic pathogens (CSP00155) 3. Managing on-farm biosecurity risk in wheat through pre-emptive breeding (DAN00174) 4. National Barley Foliar Pathogen Variety Improvement Program (DAQ00187) 5. Improved resistance to oat pathogens and abiotic stress management (DAS00133) 6. Mining the ICARDA germplasm collection for biotic and abiotic priority traits (ICA00010)

	7. Pre-emptive chickpea pre-breeding for biotic stresses and germplasm enhancement for abiotic stresses (ICA00011) 8. Managing on-farm biosecurity risk through pre-emptive breeding: the case of rust in field pea and lentil (CUR00020)
Virus Resistance – multiple investments	1. New tools and germplasm for Australian pulse and oil seeds breeding programs to respond to changing virus threats (DAN00202) 2. Effective control of barley yellow dwarf virus (BYDV) in wheat (UT00030)
Septoria Resistance	Effective genetic control of Septoria tritici blotch (DAN00203)
Stagonospora Resistance	Effective genetic control of Stagonospora nodorum blotch (DAW00248)
Phytophthora root rot Resistance	Managing Crop Disease - Improving chickpea pathogen resistance (DAN00172)

Issue 7 - Disease management package for sclerotinia, blackleg and powdery mildew in canola

Foliar diseases are considered to be a significant factor limiting yield potential of canola crops in the high rainfall zone. The main foliar diseases include blackleg flower, stem and pod infections, sclerotinia and powdery mildew. Conditions in high rainfall environments favour the infection and spread of these diseases in canola crops. In recent years, there has been an increase in the range of diseases and levels of infection in canola crops across the high rainfall zone. An improved understanding of the epidemiology, yield loss and economic impact is essential to the development of cost-effective disease management strategies.

GRDC investments addressing this issue

National canola pathology program (UM00051)	This project will provide disease management strategies for canola growers across all canola growing regions. This will be achieved by: 1. Monitoring disease incidence and severity of blackleg, sclerotinia and other diseases 2. Monitoring effectiveness of blackleg disease resistance in cultivars 3. Advising canola growers on cultivar choice and best practices to manage disease both regionally and nationally. BLACKLEG: All commercial cultivars have been placed into blackleg resistance groups (A-H and S) based on their complement of resistance genes. Frequency of isolates virulent towards cultivars with Rlm1 and Rlm4 resistance varies regionally and reflects intensity of canola production, the complement of resistance genes sown and selection pressure in that region. Spraying with the fungicide Prosaro can decrease blackleg severity, but in most situations is not economically viable. Isolates with increased tolerance to fluquinconazole have been identified; since canola production now in many regions relies on fungicide use, this needs to be investigated further. Under particular environmental conditions, blackleg is now infecting the stem and branches of plants (referred to as upper canopy infection). This is leading to severe yield loss in some situations. Delaying flower time and strategic application of fungicides can reduce upper canopy infection. In addition, blackleg can infect pods, leading to infected seed, which has a low germination rate and seedling blight in untreated. Plants derived from this seed can develop stem cankers. SCLEROTINIA Surveys of commercial crops showed widespread Sclerotinia stem rot in high rainfall districts of WA and southern NSW. Fungicide trials in WA showed that Prosaro sprays at 10% and 50% bloom reduced disease incidence and increased yield, compared to the nil fungicide treatment. Trials investigating time of flowering on sclerotinia incidence showed no significant relationship between cultivar and disease incidence. Preliminary experiments show relationships between

	humidity, rainfall events and development of stem rot; this knowledge will be used in a predictive model. DISEASES OTHER THAN BLACKLEG AND SCLEROTINIA Incidence and severity of other diseases were surveyed at 31 sites across Australia. In 2016, white leaf spot and downy mildew were detected at low frequency. Alternaria was detected at a higher incidence than previous years due to the wet spring.
Upper Canopy Blackleg Infection (SFS00034-B)	Four trial sites will be established in each of SA and Victoria and two experiments will be conducted at each site. **Experiment 1** will evaluate the effect of Prosaro® at a range of growth stages (after the recommended 4-6 leaf stage) on blackleg control, yield and oil content – • various timings up until bud emergence growth stage for normal crown canker control • plant elongation/flowering (to protect the flowers, stems and pods) • understand economic threshold for spraying **Experiment 2** after consultation with crop protection companies proof-of-concept studies will be undertaken to screen the potential of a range of alternative and cost-effective chemical control options that will provide protection against late blackleg infection control and crown canker. The scope of this work is limited to evaluation of products which are planned for registration and commercial launch within a maximum of 24 months from project initiation.
Centre for Crop and Disease Management (CUR00023) – research program 6 - Sclerotinia stem rot of canola	To identify opportunities to create canola varieties that have increased resistance to Sclerotinia stem rot. Canola varieties with different disease ratings were screened with 11 genetically distinct WA Sclerotinia sclerotiorum isolates. No significant difference were observed in the response to the 11 isolates. Screened a subset of 100 spring varieties for its resistance to SSR under controlled conditions and in the field. Preliminary analysis indicate different response to SSR across the 100 varieties tested in this population. We will repeat these experiments in controlled and field conditions in 2017 to confirm the presence of genetic resistance in canola germplasm and to establish a set of differentially responding canola lines. A complete Sclerotinia sclerotiorum genome assembly and annotation has been completed. 12 Western Australian SSR isolates were re-sequenced and comparative whole genome analysis to the reference genome and isolates from overseas is underway. Research investigating reports that hybrid varieties of canola are more susceptible to SSR development than OP varieties have commenced. An initial controlled environment experiment has been conducted to determine whether hybrids are more susceptible than OP varieties and this did not show a correlation. In 2017, we aim to repeat these experiments in controlled conditions and in the field.
Improving grower surveillance, management, epidemiology knowledge and tools to manage crop disease **(**DAW00229)	In lupins investigated the potential benefit from fungicide application for reduction of sclerotinia, using products and timings known to be effective in canola. Responses in disease incidence, severity and yield were recorded, indicating potential for this approach to be beneficial in high disease pressure scenarios.
Emerging foliar diseases of canola (UWA00170)	A mixture of surveys, glasshouse and field experiments are being undertaken to address the objectives above and to produce the outcomes below. An Australia-wide survey of all four foliar diseases plus blackleg leaf disease has been completed in 2015, repeated for 2016, and will again occur in the 2017 season. Molecular studies have confirmed significant variation in each of the four different pathogen populations across Australia, highlighting the need to identify canola resistances that are effective across this pathogen variation. Australian canola varieties with best resistances to the populations of the white leaf spot and powdery mildew pathogens have now been identified in field and/or glasshouse studies and the same is now being done for downy mildew and will be done later for Alternaria to provide canola growers choice in using more

	resistant varieties in situations where any one or more of these diseases are considered a significant issue. Alternaria appears to be a complex of different species and studies to define the relative importance of the different species are now underway. New understanding on the environmental and plant age influences for the first time can explain the restriction of severe powdery mildew epidemics to northern NSW and WA and similar studies are planned for the other diseases so that we can understand why the incidence and severity of each disease varies across Australia.
Blackleg NVT ratings (MGP00004)	Annual provision of canola blackleg ratings to industry Provide a service to private seed companies for the testing of their lines with the addition of seed dressing fungicide (fluquinconazole). Updating the National Blackleg Management Guide Establish 34 blackleg population monitoring sites across all canola growing regions in Australia 3) to track changes in frequency of virulence towards specific resistance genes (resistance groups). Sites will be sown alongside NVT yield sites

Issue No. 8 - Develop harvest and weed seed management techniques to deal with late germinating annual ryegrass

The high levels of resistance and longer growing seasons in the high rainfall zone means that growers do not have herbicide options to effectively control the staggered and late germinations of ARG which cause seedbanks to increase. Weed seed set and harvest weed seed tactics for ARG are required to enable growers to effectively prevent the build-up of ARG weed seedbanks and reduce ARG numbers.

GRDC investments addressing this issue

Harvest weed seed control for the southern region (SFS00032)	Develop and validate harvest weed seed control techniques for the higher rainfall and irrigation areas of the southern grain cropping region of Australia. The project Harvest weed seed control (HWSC) for the Southern high rainfall zone was implemented to evaluate the efficacy and reliability of HWSC practices in that region. Seven small plot trials have been implemented over 2015 and 2016 with the main focus being on annual ryegrass (ARG). In 2015 three trials were conducted investigating the impact of varietal phenology, time of sowing (TOS) and harvest height. three wheat varieties, early, mid and late maturity were sown a three different TOS, (early, mid & late). Each treatment was harvested at 15cm high or 30cm high to impersonate HWSC harvest technique (15cm) or the more traditional harvest heights of 30cm. All harvest trash was captured in bags and removed to prevent any ARG weed seed that entered the plot harvester being placed back on to the plots. Weed seed shedding prior to harvest was collected in two trays per plot to determine numbers of weed seeds escaping the HWSC system. In 2016, as a result of no significance of any treatments in 2015 on ARG soil seed bank numbers, trials were sown to one variety at one TOS and harvested at the same height as used in 2015. This would provide large numbers of replications to smooth out impacts of ARG weed density variation. Native populations of ARG across all sites were highly variable as evidenced in 2015. Four on farm trials were also implemented in in 2015 and another 4 on farm demonstrations in 2016. Two were at existing sites from 2015 and two were new sites in 2016.
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.
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.
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, brome grass, 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 brome grass 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, brome grass, fleabane, and witch grass 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 brome grass 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.
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. 9 - Develop new (non GM) canola varieties

Growers require access to a range of improved canola varieties with a range of traits that are adapted to high rainfall environments. Regulations in South Australia and Tasmania prevent the growing of GM varieties. As a consequence growers in key high rainfall production areas in these States do not have access to GM varieties with a range of improved traits (e.g. herbicide resistance, pod strength to reduce shattering).

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. 10 - Accelerated development of waterlogging tolerant barley

Large areas of the high rainfall zone are prone to waterlogging which limits yields and profitability. Barley is less tolerant of waterlogging than other cereal crops. The GRDC has invested in research undertaken by the Tasmanian Institute of Agriculture (TIA) which has identified a major gene controlling the tolerance of waterlogging in barley. Further research is required to develop molecular markers which would accelerate the introduction of this gene and the breeding of varieties with greater waterlogging tolerance.

GRDC investments addressing this issue

University of Tasmania (UT00027)	Over the last 15 years the University of Tasmania has been working on barley waterlogging tolerance. Recently they identified germplasm (a wild barley) with waterlogging tolerance, and have subsequently developed molecular markers linked to the tolerance genes that can be effectively used in breeding programs. The tolerance gene controls the development of aerenchyma in roots under waterlogging conditions. Although these project outputs have been made available to barley breeders for varietal improvement, GRDC is currently investigating whether the introgression of this tolerance into elite breeding lines can be accelerated through further investment. Specifically, whether the TIA screening facility and tissue culture techniques (5-6 generations a year) can be used to assist breeders to more rapidly introduce waterlogging tolerance genes into elite breeding germplasm. The objective being to ensure the most rapid delivery of new varieties with waterlogging tolerance to growers in the HRZ.
Genotype and management combinations for highly productive cropping systems in the HRZ of southern Australia (DAV00161)	Advice to plant breeders on the characteristics required for high yielding, disease resistant, milling quality **wheat and barley varietie**s in the high rainfall zone. Advice to plant breeders on the characteristics required for high yielding, disease resistant quality pulses and oilseeds suitable for rotations with **wheat and barley** in the high rainfall zone. A 'model' of crop requirements for the HRZ based on existing agronomic, climate and soil data which will be used to plan treatments, interpret results, define suitable germplasm and provide information to growers to aid in management decisions.