

**SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT
REFERENCES COMMITTEE**

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**Inquiry into industry structures and systems governing the imposition of and
disbursement of marketing and research and development (R&D) levies in
the agricultural sector**

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Description of Issue

Frost related crop damage has been a major issue for grain growers in the past. Over the past year frost damage at the vegetative stage was very extensive.

GRDC continues to make significant contributions to research in this area.

Statistics and Funding

GRDC have increased investment in frost research and in 2014 established the National Frost Initiative (NFI), an integrated program which addresses genetic, management and environmental approaches to mitigate the effects of frost in the Northern, Southern and Western cropping regions of Australia.

- GRDC invested approximately **\$13.2 million** in frost related research and development between 2002 and 2013.
- **\$16.3 million** has been committed for the period 2014 to 2019.
- A breakdown of funding for some of individual projects can be found below.

The following table refers to some current GRDC funded projects:

Project	Organisations	GRDC Budget
Australian National Frost Program	University of Adelaide/DAFWA	\$2,500,000 over 5 years
Frost tolerance in wheat	University of Adelaide	\$662,487 over 3 years
New strategies for phenotyping reproductive stage frost and chilling tolerance in wheat.	CSIRO PI Canberra/DAFWA	\$911,506 over 3 years
Spatial temperature measurement and mapping tools to assist growers, advisors and extension specialists manage frost risk at farm scale	CSIRO PI Canberra/DAFWA, SARDI, UWA, VIC DEPI	\$2,000,000 over 4 years
Focused identification of germplasm for specific traits	ICARDA, Lebanon	\$713,860 over 3 year
Managing Potassium Nutrition to Alleviate Crop Stress	Murdoch University	\$596,672 over 3 years
RCS, Albany – Grazing crops for frost mitigation	Southern Dirt Inc, Albany WA	\$13,600
Understanding frost risk in a variable and changing climate	CSIRO	\$416,354 over 3 years
Determining the relationship between frost tolerance and yield in the field	CSIRO	\$1.5 million over 3 years
Frost situation analysis	DAFFQ	\$300,000 over 2 years

The following table refers to current short term regional projects in the Western cropping region:

Project	Organisations	GRDC Budget
Use of chemicals to increase frost hardness in wheat	University of Western Australia	\$40,000 over 1 year
Remote sensing of frost-induced stress in wheat paddocks	University of Western Australia	\$40,000 over 1 year
Frost Mitigation using Grazing crops	ConsultAg	\$35,000 over 1 year
Stubble management to reduce the impact of Frost to crops in the Albany and Kwinana West Zone of WA	Living Farm	\$40,000 over 1 year
Effect of stubble retention on canopy temperature and frost damage in wheat	Facey Group	\$25,000 over 1 year

Talking Points

- Frost is an annual production constraint for the Australian grains industry. Each year, at least one area in the Australian grain growing region is affected by frost damage.
- Frost is uniquely challenging in terms of its sporadic nature, its unpredictability and of course the magnitude of its severity when it occurs.
- It is estimated that frost related damage costs the Australian grains industry about **\$360 million** per annum.
- From results of modelling projects under the GRDC funded Managing Climate Variability program, we know that the frequency and severity of spring radiation frosts is increasing in many parts of the Australian cropping region.
- In 2012, the impact in WA was particularly great, with an estimated \$100 million loss in productivity.
- In the 2013 season many parts of the Australian grain belt experienced crop or yield losses as a result of frost events.
- In 2014 the southern region of Australia (SA, Victoria and parts of NSW), severe and prolonged incidence of frost occurred during August which resulted in significant yield losses.
- Reports of frost were received from upper Eyre Peninsula, Upper North, Mid North, Lower North, and the Mallee in South Australia, the Mallee and parts of the northern Wimmera in Victoria, and southern New South Wales.
- Depending on the region the affected crops were wheat, barley, vetch, canola and lupins, oats, beans, oats.
- Damage through south-east Australia was severe and widespread with some reported total crop loss because of a combinations of stem and flowering frosts
- Reports indicated that some growers choose to cut their crops for hay
- Frost susceptibility data for most commercial wheat is now available after three years of research across Australia as part of the GRDC's National Frost Initiative.

- The results are available on the National Variety Trial website (www.nvtonline.com.au) and are based on each variety's relative susceptibility to spring radiation or reproductive frost, which occurs in late winter to early spring.
- This GRDC's investment is an example of a significant pre-breeding project which is developing industry capacity and methodologies that will enable not only the independent screening of newly developed cultivars from commercial breeding companies but also introduced germplasm to identify increased levels of frost tolerance for Australian growers

GRDC Funded Research

- Frost R&D continues to be a high priority research area for GRDC.
- GRDC doubled its investment over the next five years with \$18.5 million committed to projects from 2014 to 2019; following an investment of approximately \$11.1 million in frost related research, development and extension between 2003 and 2013.
- In our effort to tackle frost we invest in long term initiatives as part of the National Frost Program and short term projects driven by regionally identified issues.

National Research

Since 2012, GRDC has applied a 'Program Logic' approach to determine and prioritise frost research investments, with RD&E investments directed to activities that most efficiently deliver the following three practice changes necessary to reduce the impact of frost:

1. Growers in frost prone areas with access to and using cereal varieties with reproductive frost tolerance superior to current dominant varieties.
 2. Growers in frost prone areas implementing management practices that minimise the impact of frost events
 3. Growers employing frost risk management tools to inform varietal choice and management practices.
- Through its investment in the National Frost Program, the industry now has a field frost screening method that is robust, accurate and reproducible.
 - For the first time GRDC funded projects with the University of Adelaide and Department of Agriculture and Food WA (DAFWA) will use data collected with this screening method to establish wheat and barley frost tolerance ratings. These ratings will be released in February 2015 (in time for the 2015 season), helping growers to select the best varieties for their farming system and manage the risks associated with frost.
 - In addition, the screening method allows us to shift to a new phase of screening thousands of wheat lines from around the world to identify the most frost tolerant genes for future breeding programs. Over the next 5 years, thousands of wheat lines will be tested.

Regional Research

- GRDC invests in regional research that focuses on products and farming system techniques, such as stubble management and chemical application that can be combined with superior cultivars to further boost tolerance.

- While the work is being done in the West, it is likely that the research results will be transferable to the Northern and Southern regions.
- Following successful EIP in 2013, GRDC initiated projects to investigate the capacity of different farming systems practices to reduce the impact of frost events. This covered research into managing stubble, crop nutrition and the application of putative frost protection chemicals.
- Similarly following another EIP in 2014, GRDC is contracting a research consortium led by CSIRO PI Canberra that includes DAFWA, SARDI, UWA, VIC DEPI to assess the utility of different spatial temperature measurement methods such as satellite, aerial, high density temperature data logger arrays and others to determine whether the accuracy of investigated methods are sufficient to reliably map crop temperature differences of 1°C or less and whether the resolution of investigated methods is amenable to farming

Some of the Key R&D Projects

Frost Situational Analysis Project - (\$300,000 over 2 years)

- The accuracy of estimates of direct and indirect frost losses is unclear since the quality of data regarding annual losses is highly regional dependant with some regions based upon anecdotal assessments rather than more robust field or modelling data

The Australian National Frost Program - (\$2.5 million over 5 years)

- This project was established in 2012 by UA, DAFWA and GRDC. The project was born out of recommendations from a national frost workshop conducted by GRDC. The workshop revealed that efforts to develop cereal cultivars with enhanced reproductive frost tolerance were being undermined through lack of an accurate and reproducible field frost phenotyping method.

Frost Tolerance in Wheat - (\$662,487 over 3 years)

- Utilising the phenotyping method, the University of Adelaide have identified a synthetic derived wheat line (AUS30323) which has lower levels of floret sterility under mild frost events than many dominant new wheat varieties.
- This project seeks to determine the genetic basis of tolerance in AUS30323 and generate tools (molecular markers) that wheat breeders can use to exploit its tolerance in their breeding programs.

Expanded Frost Phenotyping - (\$300,000 over 3 years)

- A GRDC funded project with CSIRO has developed near isogenic wheat lines (NILs) which have a common genetic background and differ only in the type and combination of flowering genes they carry.
- This project will use the NILs to investigate whether individual variants (alleles) of flowering genes and/or combinations can convey increased frost tolerance in wheat.

New strategies for Phenotyping reproductive stage frost and chilling tolerance in wheat - (\$911,506 over 3 years)

- The aim of this project is to investigate how adaptation of wheat plants to reproductive-stage chilling conditions contributes to frost tolerance.

- Findings from the ANFP have highlighted varietal difference in wheat floret sterility under chilling conditions in WA and SA, when there are no visible signs of freezing damage.
- Therefore, developing commercial varieties tolerant to frost will require wheat plants to be able to survive the chilling in the first place, regardless of whether there is tissue damage from freezing.

Spatial temperature measurement and mapping tools to assist growers, advisors and extension specialists manage frost risk at farm scale - (\$2,000,000 over 4 years)

- This project will examine available satellite and other spatial information to develop high resolution frost risk maps at successive resolutions i.e. 5km, 30m, 5m and sub 1m (where feasible) for case studies across the Australian wheat belt.
- Examine effective ways to rapidly assess post event damage and test/calibrate the tools against existing national frost trials to determine which tools most effectively capture the spatial variation in frost risk.
- Consolidate the knowledge products generated as part of the research activities into a "Frost watch" program to be trialled with farmer groups. This information would support producers to farm plan for better frost protection, and improve their assessment of damage and exploration of effective production responses.

Focused identification of germplasm for specific traits - (\$713,860 over 3 years)

- The GRDC has funded a project aimed at developing methodologies to identify small best-bet subsets of germplasm from global plant genetic resource collections that will maximize the chances of finding the desired traits in a manageable set of genotypes.
- The resulting approach (FIGS) has proved successful at identifying bread wheat landraces tolerant to abiotic stresses and containing new genes for tolerances to both insect pests and diseases.

Managing Potassium Nutrition to Alleviate Crop Stress – (\$596,672 over 3 years)

- This project will utilise replicated field trials and differing fertiliser regimes to investigate the relationship between K nutrition and reproductive frost damage in the Western cropping region with data extended nationally. The project links to the ANFP field evaluation program in WA.

Understanding frost risk in a variable and changing climate (\$416,354 over 3 years)

- This project is aimed at understanding the changing nature of frost risk as an extreme and catastrophic event for the southern regions of Australia and implications for the grains industry.
- The project is examining changes in frost frequency and occurrence from a range of climate information sources including reanalysis of climate data, interpolated climate surfaces information, and/or selected high quality temperature recording stations.
- The project will establish an empirical relationship between major synoptic features and prevailing frost risk as well as examine how the frequency and duration of these synoptic features may change in response to global warming.

Use of chemicals to increase frost hardiness in wheat (\$40,000 over 1 year)

- A mini literature review will be conducted and the manuscript published in relevant journal.

- The literature review will aim to explore additional candidates as chemical compounds that can induce frost tolerance in wheat and expand our understanding related to physiological responses induced by abiotic stress such as post-heading radiant frost in wheat plants.

Remote sensing of frost-induced stress in wheat paddocks (40,000 over 1 year)

- This project will test the use of remote sensing (e.g. data derived from satellite imagery - current and historical) to differentiate and map areas in the paddock of frost-induced stress at the anthesis/milk development stage of winter wheat.

Frost Mitigation using Grazing crops (\$35,000 over 1 year)

- This project will build on the knowledge of exploratory trials conducted in 2012 which aimed to show that there is a benefit to sowing early, grazing the crop (providing feed value), removing the stock and then harvesting as per normal practice.
- This tactic aims to delay flowering, thereby reducing the risk of frost and ultimately increasing grain yield.

Stubble management to reduce the impact of Frost to crops in the Albany and Kwinana West Zone of WA (\$40,000 over 1 year).

- This projects aim to gather additional information on the impact of stubble management to reduce the impact of frost. It is building on work from 2012 which demonstrated a positive benefit to removing stubble.
- A smaller component of this project is looking at the effects of foliar applications of copper to improve crop tolerance to frost and will be undertaken near Lake Grace and Corrigin in the West.

Effect of stubble retention on canopy temperature and frost damage in wheat (\$25,000 over 1 year)

- This projects aims to record the temperature variation across the slope of a continually cropped site. Within the site there will be plots of burnt stubble and retained stubble (consistent with current grower practices) up and down the slope within a site.
- The scale of the trial will be based on farmer equipment and aims to provide a more practical approach for on farm management to address whether stubble management in a continuous cropping rotation influences the effect on frost incidence in wheat.

ACPFG

- ACPFG are investigating whether modifying the expression pattern of DREBs so that they are active during flowering can provide reproductive frost tolerance in Australian spring-type cultivars.
- To date the ACPFG have produced barley and wheat transgenic lines for two DREB genes, driven by either continuous or stress inducible promoters.
- These have shown to have elevated vegetative cold tolerance and are currently being tested for reproductive tolerance.