South East Australian grain growers and advisors rate grain filling heat as a greater risk than frost

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Abstract
DEDJTR undertook an email survey in November 2013 to understand the current perceptions of the grains industry to management and impacts of climate volatility on crop production. The 111 responses were widespread throughout the grain growing areas of south-eastern Australia, with Victoria and the NSW Riverina predominating. The majority of grower responses came from those operating larger farms. For cereal crops, 68% and 77% of respondents were either moderately or very concerned about frost damage at flowering or heat stress damage during grain filling, respectively. For the median of participants, frost damage was perceived to happen two to three times a decade, and four out of ten years for heat shock. The overwhelming response (60%) was that heat stress was perceived to have the greatest effect on cereal crop yield than frost. Data was also collected for pulses and canola. Mitigation techniques favoured for frost damage to crops were, either sowing a mix of crop types and/or manipulating maturity time through crop/cultivar choice. Growers rarely delayed sowing to avoid the frost window. Mitigation techniques favoured for heat shock to crops were by sowing early and/or sowing a range of crop types. Growers generally did not sow early maturing crops. This survey provides a valuable snapshot of industry knowledge and perceptions around the impacts of extreme heat and frost, as well as the potential mitigation techniques being used; with the results being used to inform crop modelling and extension activities.

Introduction
Crop production across Australia is being increasingly impacted by a changing climate and highly variable weather as the average annual daily mean temperatures have increased progressively since the middle of the 20th century against a backdrop of natural year to year variability (CSIRO and Bureau of Meteorology 2012). One of the key challenge for crop production is the change in climate extremes, both the increased frequency of very hot (>40°C) daytime temperatures since the 1990's (CSIRO and Bureau of Meteorology 2012) and the increased incidence of frost across the Australian grain belt between 1960 and 2011 (GRDC Groundcover November 2012). Extreme weather events, such as frost and heat shock (short period of very high temperatures (>33°C)), are reducing crop production and represent a substantial challenge to the Australian grain industry. We conducted a survey of farmers and their advisors to gauge their perceptions of these issues and how they were managing it.

Methods
A web survey (SurveyMonkey) was used in the collection of data to gauge the perception of the grains industry of the risk and relative impact of extreme temperature events on production. The survey was sent out to 1809 people and was open from mid-October to November 2013. The lists consisted of 1431 farmers, 326 agribusiness and 53 government agronomists. Initially the distribution list was sought from those growers and agro consultants of the DEDJTR's 'The Break' newsletter and subsequently expanded to include the GRDC's monthly information email list and also the Pritchard Agro consultant distribution list. Individual responses were identified by postcode allowing approximate spatial mapping of results.

Results and Discussion
Responses from 132 people were collected, of which 111 were sufficiently complete or legitimate survey responses. The majority of the respondents were growers (72%) and the remainder advisors. This reflects the ratio of farmers to advisors in the email distribution list, with a response rate of 8% for advisors and 6% for growers respectively. The regional location of respondents was widespread throughout the grain growing areas of south-eastern Australia, with responses from Victoria (69%) and the NSW Riverina (10%) predominating. When asked about perception of the incidence of frost damage in cereals, the response is wide ranging, but the median response of participants was that frost damage occurs two to three times every

decade (Figure 1). Five people reported they were unsure. No respondents thought their risk was at the extremes of never or all the time.

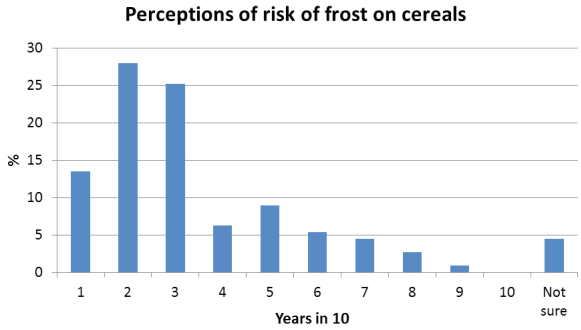

Figure 1. Respondents' perception of the likelihood of frost damage to wheat during the reproductive and grain filling phase (n = 111).

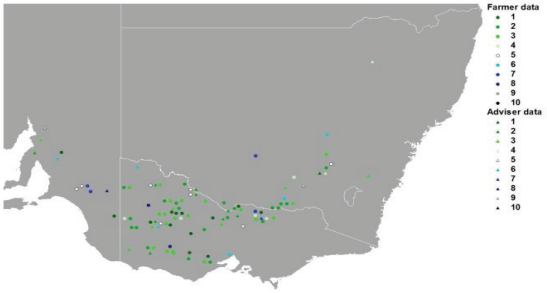

Figure 2. Geographic spread of responses to the number of years out of 10 that respondents think frost affects wheat near flowering.

When this data is spatially represented across south eastern Australia it shows that the perceived frequency of 1-to-3 years per decade occurs over most of the region, but also shows where the higher perceived risks exist (Figure 2). There appears to be no pattern except in the south east Mallee of South Australia where a cluster of growers believe they are affected quite often (>50% of years). DEDJTR modelling research shows that this area in the South Australia Mallee is a moderate frost risk when planting a mid-season variety on an autumn break of 25 mm rain (Barlow et al. 2013), however this modelling does not take into account the selection of sowing time and crop variety which may be aimed at avoiding warm dry conditions at the end of the grain-fill period. In contrast, while this modelling suggests that the west Wimmera of Victoria has a chance of frost around flowering in 40-70% of years, this frequency of risk was not reflected in the survey responses.

There appear to be a number of respondents who perceived a high frequency of frost risk randomly scattered through the study region (Figure 2). Some of these responses are in close proximity to those that perceived a much lower risk. While regional differences are an important consideration in understanding frost risk, differences in topography and management strategies within a region mean that it is possible that seriously affected farmers can farm close to people who have never been affected during their farming career. It's also likely that some farmers have a poor understanding of their historic frost risk.

When asked about the strategies used to mitigate against frost damage in cereals, most farmers and advisors used the selection of crop types and varieties with different maturities regularly (Table 1). Sowing time, a commonly recommended strategy to mitigate frost risk (Rebbeck and Knell 2007), either through delayed sowing or sowing across a mix of times, was not commonly used by respondents. Sowing at a mix of times was sometimes used and fewer people chose to sow later to reduce the risk of frost around flowering. This is not surprising, as there are known costs in terms of production from delayed sowing due to warmer drier conditions later in the season. The large number of respondents (59%) who never delay sowing suggests that growers are mainly considering the yield penalties from later sowing over the potential frost advantages. Interestingly some growers did treat their more frost prone areas differently or grow less of the susceptible crops. The number of respondents treating areas differently (19%) indicates a number of growers actively mitigating their frost risk in the known problem areas.

Table 1. The range of management option recommended or used by growers to mitigate against frost damage in cereals

	All the time	Most of the time	Some of the time	Never
Sowing a mix of crop types	26%	36%	28%	10%
Sowing a mix of crop maturities	20%	33%	37%	10%
Sowing at a mix of times	5%	16%	47%	32%
Delaying sowing	3%	2%	37%	58%
Treating frost prone areas differently	9%	10%	32%	49%
Grow less of the most susceptible crops	7%	13%	48%	32%

When asked about their perception of the risk of heat stress, the answer is very broad varying from 10-100% of years (Figure 3). DEDJTR modelling research shows there is a significant variation in the risk of heat shock during the grain filling period throughout the study region. When the modelling was conducted using a mid-season variety on an autumn break of 25mm rain, the years in which a heat shock event occurred during grain fill ranged from the 0-10% category up to 90-100% (Barlow et al. 2013).

The spatial assessment of these responses shows a greater level of uncertainty than for frost (Figure 4). Some respondents match the DEDJTR modelled analysis, but many exceptions exist where people's perceptions of heat risk are very different to their neighbours. Unlike frost risk, altitude and land aspect have much less influence on heat shock, so such large differences in incidence are unlikely to be real. There is clear evidence that people's perception of heat risk damage and yield penalty is not as clear as for that of frost, which is highly visual. Unlike frost, where damage is visible within a couple days to a couple weeks, heat damage may not be observed till harvest.

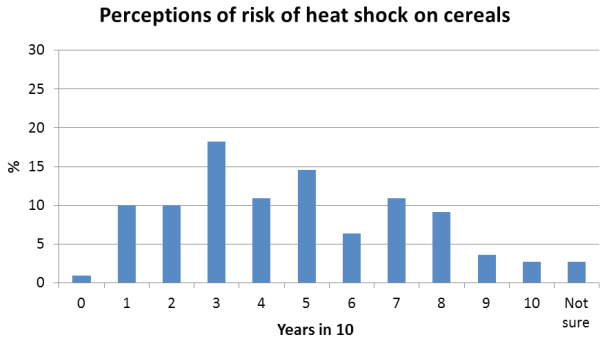

Figure 3. Respondents' perceptions of the risk of heat shock at flowering and grain fill in cereals (n=111).

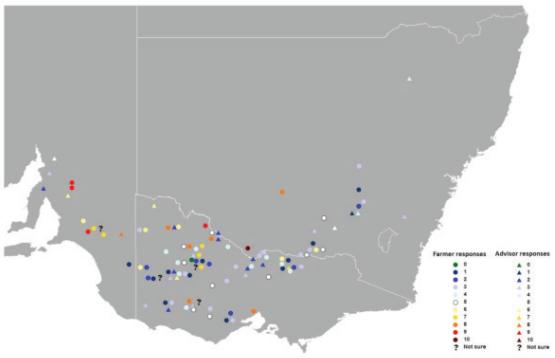

Figure 4. Geographic spread of responses to the number of years out of 10 that respondents think heat shock affects wheat at flowering and grain fill.

When asked about the ways that they mitigate against heat shock most farmers and advisors are sowing early and sowing a mix of crop types (Table 2). The use of early maturing varieties is surprisingly less common and once again varying sowing date is not popular. The selection of less susceptible crops is also not used regularly with 29% saying they never do it. The prevalence of early sowing against heat aligns with the practice of never sowing late for frost control. Early sowing in the frost window or even before the frost window often leads to a good outcome in the absence of a frost event due to grain fill occurring before heat stress occurs. This data highlights that growers are more intent on avoiding late season heat shock to crops by sowing early, more so than avoiding frost by sowing later.

Table 2. A comparison of popularity of a range of agronomic management options that are used or recommended to mitigate against heat shock in cereals.

	All the time	Most of the time	Some of the time	Never
Sowing early	16%	36%	35%	13%
Sowing earlier maturing varieties	10%	24%	53%	13%
Sowing a mix of crop types	19%	40%	26%	15%
Varying sowing dates	10%	22%	45%	23%
Grow less of the more susceptible crops	9%	18%	44%	29%

When this data is spatially displayed it shows that heat is clearly the greater concern, but the people who are concerned about frost are located to the west and north of the Great Dividing Range, with the exception of some of south-western Victoria respondents (Figure 5). Modelling work by DEDJTR has looked at the relative risk (low less than 33%, and high greater than 33% of years) of heat and frost occurring for a mid-season wheat sown on a defined autumn break (Barlow et al. 2013). There appears to be a good correlation between the perceived risks of respondents and the likelihood of frost and/or an extreme heat event.

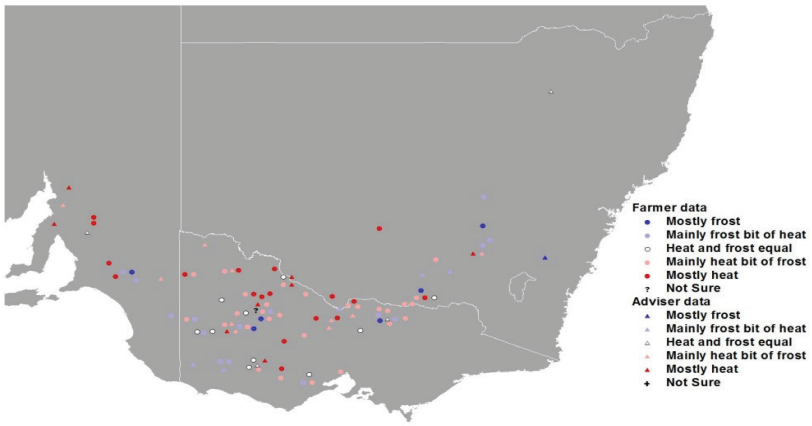

Figure 5. Geographical spread of respondents' perceptions of the relative effect of heat and/or frost on cereal yield.

Conclusion

This survey has provided a timely and useful snapshot of industry knowledge of climate variability shocks and their mitigation tools. Useful responses from 111 people were obtained with respondents spread throughout the grain growing areas of south-eastern Australia, with Victoria and the NSW Riverina predominating. The risk of frost was assessed by respondents as most commonly between 10% and 30% of the time whereas the risk of heat was less defined, varying between 10% and 80%. People's assessment of heat risk is more varied and warrants further work on both the effects and communication of heat risks.

A large number of respondents (59%) have never delayed sowing as a frost evasion strategy, suggesting that growers are mainly considering the yield penalties, associated with heat stress and drought, from later sowing over the potential frost advantages. The number of people treating areas differently to a larger extent (19%), indicates some farmers actively mitigating their frost risk in the known areas problems occur. Farmers are managing heat stress by sowing earlier with a mix of crop types, but the use of earlier maturing varieties is not widespread. The mitigation options the grains industry employs to avoid heat stress are not used with the same conviction as those to avoid frost.

Overall, the results from this survey have shown that growers and consultants are more concerned with heat stress than frost. However, these perceptions have likely been influenced by the millennium drought where heat stress and terminal drought at the end of the growing season were the dominant climatic challenges. There was evidence that the impact of heat shock on yield is not as clearly understood as the impact of frost.

Acknowledgements

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References

Barlow K, Christy B, O'Leary G, Riffkin P, Nuttall J (2013) Simulating the impact of extreme heat and frost events on wheat production: the first steps. In '20th International Congress on Modelling and Simulation. '. (Eds J Piantadosi, R Anderssen and B J) pp. 545-551. (Modelling and Simulation Society of Australia and New Zealand: Adelaide)

CSIRO, Bureau of Meteorology (2012) 'State of the Climate 2012.' In (CSIRO and BoM) Available at www.csiro.au/State-of-the-Climate-2012

Rebbeck M, Knell G (2007) Managing frost risk: a guide for southern Australian grains. South Australian Research and Development Institute and Grains Research and Development Corporation, Canberra, Australia.

Wahlquist A (2012) Researchers probe warming climate frost puzzle. In 'Groundcover. Vol. 101'. (Grains Research and Development Corporation: Kingston ACT, Australia)