Climate change research at SCRI

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Climate change is widely recognised as the most serious environmental threat facing the world today and is becoming central to policy making and land use decision-making. The climate change predictions for Scotland include increased temperatures, seasonal changes in precipitation patterns resulting in both drought and flooding/waterlogging, longer growing seasons and more extreme weather events. The Scottish Government has set ambitious targets in its Climate Change Strategy, announcing a proposed target for reduction of greenhouse gas (GHG) emissions of 80% by 2050. Much of the science research being carried out at SCRI is about providing the tools and resources for both mitigating climate change and adapting to its consequences, essential components of the strategies which must be implemented to achieve these policy targets. In many respects climate change related research is what we have been carrying out successfully for many years which has advanced the utility of our crops. However, recognition of the global nature of the change, its man-made cause and the enormous scale and seriousness of the consequences has reemphasised the importance of developing sustainable and resilient solutions to the environmental changes we are likely to face.

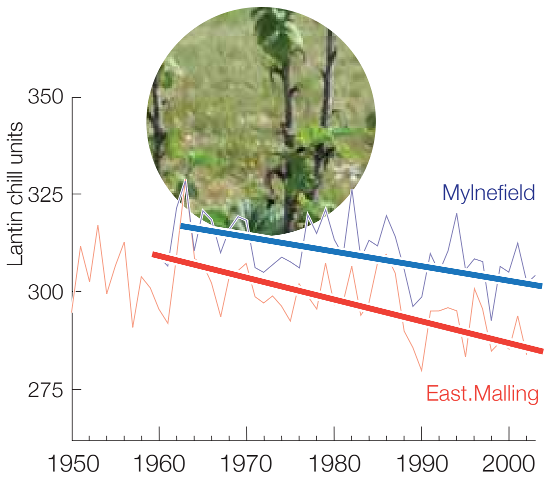

Figure 1 Comparison of long term trends data in the north and south of the UK.

Our climate in Scotland has been changing in line with the overall trend; with a mean temperature rise over the last 40 years of about 1.2°C. On the main Mylnefield SCRI site, climate measurements have been made continuously since 1959, and whilst much of the data collected is standard, it includes measurements of soil temperature at 10, 20, 30, 50 and 100cm depths and clearly demonstrates that even the subsoil is warming. This may have profound implications for the biological processes involved in carbon cycling in soils and therefore the long term health of our crop land. This is linked with other work on carbon additions to our soil using farmyard manure and municipal compost, the latter offering a potentially important means of mitigation whilst improving our crop soil. (Fig. 1) The amount of root left in the soil by crops varies with genotype and this is being studied both in controlled environments and non-destructively in the field for barley. As barley dominates the arable rotation in Scotland, this could have important implications for carbon sequestration.

The consequences of climate change, particularly milder winters, are already being seen in our blackcurrant crops where lack of winter chill results in asynchronous development, more specifically uneven budbreak and subsequently uneven ripening. In a crop which relies on machine harvesting on one occasion, this can cause severe reduction of both quality and yield. The identification of phenotypic variation in chilling requirement and understanding the molecular mechanisms controlling related processes such as dormancy release are key objectives of our research. In barley the genetic and molecular basis of control of developmental processes affected by the stresses likely to increase with climate change are similarly the focus of research projects. For example, alternative gene splice events may occur in response to stresses resulting in different gene products being made. In the case of both blackcurrant and barley research, the principles and mechanisms identified which can be manipulated in breeding are not only useful for adapting these crops to climate change, but potentially other woody perennials and cereals respectively

Pests and pathogens are organisms which are specifically adapted to exploit resources not adequately protected by plant defence mechanisms. Climate change will open new opportunities for these organisms and the populations of the peach potato aphid (*Mysus persicae*), the potato late blight pathogen (*Phytophthora infestans*) and other pathogens are being monitored in detail both quantitatively and by studying the genotypic structure of their populations to determine how much climate is driving changes, and how much is driven by factors such as varieties, agronomic practice and agrochemical control measures. These threats feature strongly in an assessment of the likely changes in pest and pathogen challenges, particularly the possible effects of climate change on aphid populations transmitting viruses to potatoes, as the virus-free status of the Scottish seed potato industry is crucial and could be threatened. Solutions via both breeding for resistance and development of crop protection methodologies are central to our research and integrating these with continued improvements in quality and yield in new cultivars is pursued through networks with plant breeders.

Climate change has implications for yield and quality too, often likely to be negatively affected either directly or from increased or changed pest and pathogen attacks. Moreover effects are likely to be less predictable as a consequence of changed precipitation patterns and more extreme weather events. Furthermore, effects of climate change on one organism may have

Controlled growth chamber with elevated CO_2.

unpredictable consequences for secondary and tertiary trophic levels. An example of this is this is shown in work carried out in our elevated CO_2 chambers on a legume and insect interaction. Under 700 μl l^{-1} CO_2 the number of root nodules increases, but so does the number *Sitona lepidus* larvae which target root nodules resulting in reduced root nitrogen per unit root dry mass.

SCRI leads the Scottish Government Rural & Environment Research and Analysis Directorate's (RERAD) Programme 1: Profitable and sustainable agriculture: plants, which has three cross-cutting themes, one of which is 'Responding to Climate Change'. Whilst we report progress of research within the theme in the context of this programme, we are increasingly moving towards work which examines the effects of climate change on all land use issues which crosses this, other commissioned research programmes and beyond since, just as climate is a complex system, so must our response be. Together with the other Main Research Providers we address not only the biological interactions, but also the socio-economic implications of adaptation and mitigation actions to direct our research priorities. Future work will be increasingly cross-disciplinary and require joint climate change research facilities which are currently being planned.