climate change

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Breeding For Climate Change: Future-Proofing The Scottish Potato Industry[i]

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1. Key Points

- The ability to adapt potato to withstand multiple pest, pathogens and environmental stresses is critical to its future growth as a major food source.
- In current breeding efforts, strong emphasis is being placed on these traits in attempts to better equip the Scottish (and global) potato industries to flourish in a changing climate.
- The genomics[ii] era is accelerating our understanding of the key genes and mechanisms underlying potato development, physiology, water and nutrient use efficiency and resistance to biotic and abiotic stresses.
- Genomic technologies provide the potential for more rapid, marker-assisted (non-GM) breeding strategies, and afford the opportunity for success with respect to better managing resistance to pests and diseases and enhancing quality and nutritive value.
- Continued review of GM policies and regulations, and associated social and political opinions, are needed to guide and determine the safest and most productive routes to potato improvement.

2. Introduction

More than a billion people worldwide eat potato, making it a critical crop in terms of food security in the face of population growth and increased hunger rates. For example, China, the world's biggest consumer of potatoes, expects that 50% of the increased food production it will need to meet demand in the next 20 years will come from potatoes. Despite this potato production is vulnerable to a wide range of abiotic and biotic stresses

Scotland has an acknowledged global reputation for producing high quality seed potato with seed exports now exceed 100,000 tonnes per annum. 75% of exports to non-EU countries are to Egypt, Morocco and Israel and so breeding varieties that are suitable not only for the changing UK climate, but also for different climatic zones is important.

However, the broadly accepted consequences of climate change mean that potato production is vulnerable to a wide range of pests, pathogens and environmental stresses.

The main environmental stresses are drought, heat, cold, mineral deficiency and salinity. Potato is very sensitive to drought and temperature stress, the latter being considered to be the most important uncontrollable factor affecting growth and yield of potato. In fact many potato varieties are so temperature sensitive that growth above the optimal average day time temperature of 14-22˚C range sees yield falling off sharply. For example, at 27˚C, yield of the cultivar Desiree plummets to nothing. This is an extreme situation but the accepted climate change predictions forecast increases in both temperature and the frequency of extreme weather events.

This change in climate will generally play into the hands of pest and pathogens, such as Phytophthora (late blight pathogen), nematodes, bacteria, viruses and insects, and without resistance adaptation by potato will require considerable pesticide inputs for those diseases that can be controlled. However, all these climate change-related

threats were foreseen some time ago and research commissioned and/or supported by the Scottish Government seeks to address these issues.

3. Research Undertaken

The James Hutton Institute is at the forefront of future-proofing the Scottish and global potato industries against climate change and to do this they have, with Scottish Government support, adopted a holistic approach to study and understand the combined pest, pathogen and environmental stresses that accompany climate changes. Indeed the interplay of one stress, such as temperature, may compromise its ability to fight another stress such as infection highlighting the need to think more expansively and in terms of real, rather than reductionist, scenarios.

If we are to ensure a future supply of potato and associated successful Scottish industries it is imperative that we better understand the mechanics of how they respond at the molecular level to the various climate change-associated stresses. JHI, along with other world leaders in potato and a pathogen science, are combining resources such as the Commonwealth Potato Collection , a germplasm bank with diverse potato types, and state of the art technologies, such as whole genome sequencing transcriptomics, metabolomics etc., to discover the genes and mechanisms of the stress responses and their interplay. This knowledge is being used along with the recently elucidated potato genome to develop molecular markers, essentially identifiers at the genetic level, for climate and pest resistance and/or tolerance and these will lead to crops that will provide sustainable yields and secure food supplies in a changing climate.

4. How does this deliver on Scottish Policy?

- Food Security - The research will ultimately deliver improved potato cultivars to the Scottish potato industry and populace thereby ensuring economic sustainability and nutrition, respectively.
- Scotland's climate change adaptation framework - The research will deliver potato varieties that will require less inputs in terms of fertilizer and water with a commensurate reduction in energy use and GHG emissions.
- Waste - By delivering potatoes varieties that are adapted to the changing climate and "weather" and extreme events leading to reduced levels of spoiled produce and waste.
- Water - Potato has a large water footprint requiring significant levels of irrigation during growth compared to other crops. The development of varieties with better water use efficiency will see this aspect of their production impact reduced significantly. Also a reduced requirement for fertiliser by enhancing, for example nitrogen and phosphorus use efficiency, will mean less inputs and a reduced likelihood of runoff and the pollution of water courses.
- Common Agricultural Policy - the development of resource use efficient potatoes delivers directly into the proposed "greening" of direct payment by strengthen the environmental sustainability of agriculture. It should be noted that the Commission is proposing to spend 30% of direct payments specifically for the improved use of natural resources.

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[i] This policy-relevant summary was derived from the reference below by Mark Taylor and Derek Stewart, James Hutton Institute, Invergowrie, Dundee DD2 5DA, January 2013. The authors all lead the key research areas at JHI that enabled the review to have a comprehensive scope:
Paul R. J. Birch, Glenn Bryan, Brian Fenton, Eleanor M. Gilroy, Ingo Hein, John T. Jones, Ankush Prashar, Mark A. Taylor, Lesley Torrance and Ian K. Toth, 2012. Crops that feed the world 8: Potato: are the trends of increased global production sustainable? Food Security 4, 477–508.

[ii] Genomics is a discipline in genetics concerned with the study of the genome, the entirety of an organism's hereditary information.