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CXC Summary Report, Impacts on Agriculture: "Potential Impact of Future Wind Speeds on Spatial Spread of Crop Pathogens in Scotland."

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1. Summary

- Climate change is expected to lead to a reduction in spring and summer wind speeds.
- Wind-borne pathogen threats to crop production are likely decrease in the future.
- The potential decrease in disease and likely yield response can be disproportionately large when compared to projected wind speed changes.
- Opportunities to reduce the environmental impact of crop production and increase the durability of limited resistance and chemical resources are likely to increase in the future as a consequence of reduced wind-borne pathogen threats.
- The potential for modelling studies that investigate the potential of novel crop disease management strategies, such as the design of 'disease-suppressive landscapes' and the development of improved disease warning systems is considerable and should be supported.

2. Introduction

The climate has changed in Scotland over recent decades, resulting in an abundance of studies that use empirical relationships to predict risk of crop infection based on climatic criteria. This approach can be criticized, however, for ignoring species dispersal capacity and for failing to account for relevant species interactions. Plant disease involves two critical species interactions: potentially very rapid reproduction, and the possibility of long-distance dispersal and establishment in a matter of days. When we overlook the fact that many plant disease epidemics are spatiotemporal processes, an assessment of the economic impacts of epidemics under climate change becomes precarious.

In this study we consider the potential effects of future wind speeds on wind-borne pathogen threats using the potato late blight (caused by the oomycete pathogen *Phytophthora infestans*) pathosystem as a model system. *P. infestans* is an excellent candidate species as it spreads through the passive wind dispersal of enormous amounts of sporangia. Further, a well-validated, high-resolution spatiotemporal model of the pathosystem is available (1-6). Potatoes have also been a key crop for Scotland for generations. We have a worldwide reputation for producing high quality seed potatoes and 75 per cent of UK seed potatoes are produced in Scotland. Last year, exports of seed potatoes to non-EU countries hit an all-time high of 77,277 tonnes. Overall, Scottish seed potato production was worth around £100 million last year.

3. Key results

- Typical spring and summer wind speed averages for present day climate in the main cropping areas of Scotland are 10.32 m s^{-1} and 8.44 m s^{-1}.respectively.
- Wind speed reductions central estimates (50%) of -0.1 m s^{-1} and -0.15 m s^{-1} are predicted for spring and summer respectively.
- Although these projected changes in wind speed for most cropping areas in Scotland are relatively small, the reduction in spore dispersal and epidemic progress and subsequent increase in crop yield were disproportionately large at the landscape-scale. This demonstrates the utility of dynamic pathosystem modelling in climatic impact analyses for crop pathogens.
- Projected wind speed changes could result in as much as a 12% reduction in the release and escape of *P. infestans* sporangia up through the potato canopy into the atmosphere above.
- The average distance travelled by detached *P. infestans* sporangia during a long-distance dispersal event could decrease by as much as 100 m in the 2080s.
- Projected wind speed changes also reduced the release, escape, and long-distance transport and deposition of propagules ranging from ± one order of magnitude difference in size than *P. infestans* sporangia.
- In a full pathosystem modelling case study, multiple spatiotemporal potato late blight epidemics were simulated in the Fife region using the real distribution of potato fields in Fife in 2011. The average number of fields infected decreased by 42 (± 11, n = 100) in the 2080s; i.e., the proportion of fields infected decreased by 6% in the 2080s.
- Consequently, an increase in potato yield of 6% (± 2.5, n = 100) was predicted in Fife for the 2080s.
- Similar results are expected for other plant disease epidemics that spread through wind-borne inoculum dispersal.

4. Research undertaken

In this study we used a suite of models to investigate the potential effects of future wind speeds on spore dispersal, epidemic progress, and final yield at the landscape-scale. We chose potato late blight (caused by the oomycete pathogen *Phytophthora infestans*) as a model system. We first investigated the effects of projected wind speed changes on the release, long-distance transport and deposition of *P. infestans* sporangia using peer-reviewed published, validated aerobiological models developed by Skelsey et al. (1,2,5). For baseline (current) climate data, we used the 1971-2000 5 km gridded Met Office datasets for monthly wind speed. Data from the primary arable areas of Scotland were considered: Moray, Aberdeenshire, Angus, Perth and Kinross, Fife, Clackmannanshire, Falkirk and Lothian regions. For future projected wind speed changes we used the spatially coherent projections (SCPs) of the UKCP09 data (http://ukclimateprojections.defra.gov.uk/). We assumed a 'worst case' future scenario and used projected wind speeds for a high emissions scenario (IPCC A1F1) and a 2080s time slice (2070-2099). Baseline (current) and projected wind speed values were averaged over the Eastern coast and lowland areas, and over spring (March-April-May) and summer (June-July-August) periods. We next investigated the effects of projected spring and summer wind speed changes on the polycyclic spread of potato late blight epidemics across large landscapes. We used the multi-scale, potato late blight pathosystem simulator of Skelsey et al. (1), and simulated late blight epidemics in the Fife region of Scotland. Data on the size and geographic location of potato production areas in

Fife in 2011 were provided by the Integrated Administration and Control System (IACS) of the Scottish Government.

5. Recommendations

As inoculum dispersal is crucial to the epidemic phase of many plant disease epidemics, and inoculum dispersal is predicted to decrease in the future, it seems likely that opportunities to reduce the environmental impact of crop production and increase the durability of limited resistance and chemical resources will increase in the future. A transition from fixed, calendar spray regimes towards heavier reliance on accurate disease forecasting, to ensure that the correct agro-chemical product is applied at the correct dose during critical periods, would therefore be advantageous, given the expected reduction in the capacity of the atmosphere to spread disease. With specific regard to the chosen case study, I recommend that the 'Smith Period' used for forecasting the occurrence of late blight in the UK should be re-examined as it is over half a century old, and there is mounting evidence that it is no longer biologically relevant given recent dramatic shifts in the virulence, aggressiveness and fungicide insensitivity of the current UK pathogen population (1). The creation and establishment of disease-suppressive agricultural landscapes that further disconnect host and pathogen populations through, e.g., strategic spatial and temporal deployment of resistance, should be further investigated as a potential means to capitalise on expected reductions in inoculum pressure and prolong the durability of limited resistance and chemical resources. This will require ongoing work to further develop our modelling tools to better understand and predict the combined influence of landscape heterogeneity, chemical management, and the genetic composition of host populations on the spread of plant disease epidemics across large geographic areas.

6. Policy implications

- Scotland's climate change adaptation framework (7) - The research will deliver novel management strategies that reduce agro-chemical inputs in crop production.
- Food Security (8) - The research will deliver integrated management strategies that increase the durability of limited resistance and chemical resources, thereby ensuring economic sustainability.
- Water (9) - The research will deliver improved disease forecasting systems that have the potential to reduce chemical inputs, meaning a reduced likelihood of runoff and the pollution of water courses.

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7. References

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