

Future Risks of Potato Blackleg in Scotland

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1. Key points

- Potatoes are a leading Scottish product with an estimated sector value of around £170 million.
- Scotland is one of Europe's largest potato seed producers with a value of around £80-100 million.
- 75% of UK seed is produced in Scotland and 80% of UK seed exports are from Scotland.
- Scotland exports over 300,000t of seed (ca £72m), including to EU (ca £44m) and to over 25 non-EU countries (a record breaking year for non-EU exports in 2015/16) (ca £28m).
- Potato blackleg, caused mainly by *Pectobacterium atrosepticum*, is one of the most significant bacterial diseases affecting potato production in Scotland and is the main cause of seed failure and downgrading (up to 9% in 2011-12).
- In this study we used controlled environment experiments to quantify the disease-severity risk of blackleg under different temperature regimes.
- A model was developed and fitted to data for three *Pectobacterium* strains and one *Dickeya* strain.
- The model was used to project the future risk of crop damage due to blackleg for a range of time periods and CO₂ emissions scenarios.
- We found that projected increases in temperature will result in increased risk of blackleg caused by *P. atrosepticum* in Scotland.
- Conditions are expected to favour *P. atrosepticum* over the other isolates investigated, therefore *P. atrosepticum* is expected to continue to dominate in Scotland unless new populations evolve that are better adapted to warmer conditions.
- Although beyond the scope of this study it is likely that similar trends, with regards increasing incidence of blackleg, will be observed in other Northern European potato producing countries.

2. Introduction

Potato blackleg, caused by *Pectobacterium* and *Dickeya* species, is one of the most significant bacterial diseases affecting potato production globally (1). In Scotland, blackleg disease is caused exclusively by *Pectobacterium* species, with the vast majority of cases being *P. atrosepticum*. Potato blackleg is a longstanding problem in Scotland, as in many other potato growing regions of Europe and elsewhere, and although incidence has been significantly reduced since the 1960s, thanks largely to the efforts of growers and changes to industry practices influenced by research and development funded by the Scottish Government and levy boards (AHDB Potatoes), recent years have seen a marked upward trend in blackleg in seed potato crops (2). In Europe, blackleg is caused by *P. carotovorum* subsp. *brasiliense* (Pbr), *P. wasabiae* (Pwa) *Dickeya* species, including *D. solani* (3). *Dickeya* species. Pbr and Pwa have a higher optimal temperature for disease development, therefore there is a concern that these species could cause increased disease problems as Scotland's climate warms. A climate change risk assessment for potato blackleg is therefore required to guide strategies for agricultural adaptation to climate change in Scotland.

3. Research undertaken

A tuber slice assay was carried out to assess the disease severity of a range of *Pectobacterium* and *Dickeya* isolates at five different temperatures. Maris piper tubers were surfaced sterilised and cut into 7mm thick slices using a sterile knife. A core was removed from the centre of each slice to make a well 5mm deep and 7mm in diameter. The slices were inoculated by pipetting 50µl of a 10^7 CFU/ml bacterial suspension into each well. Three potato slices obtained from three different potato tubers were used for each bacterium tested, and additional slices were inoculated with 50µl of buffer to serve as a control. The tuber slices were placed on petri dishes and positioned randomly in a sealed humid box and incubated for 72 hours at the five temperatures. Disease severity was expressed as the mean diameter of the soft-rotted tissue area (lesion length). The entire experiment was independently replicated twice.

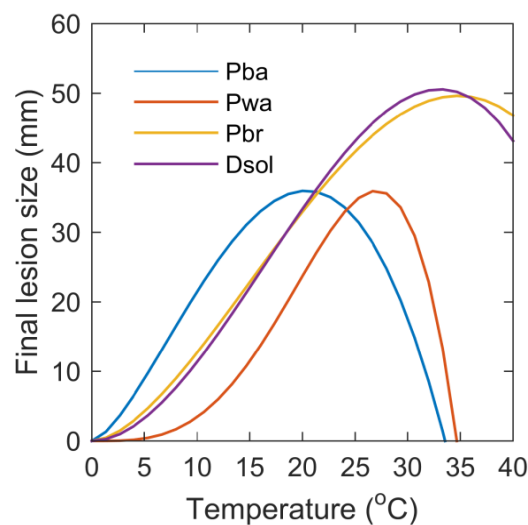


Fig. 1. Comparison of fitted curves for *Pectobacterium atrosepticum* (Pba), *P. wasabiae* (Pwa), *P. carotovorum* subsp. *brasiliense* (Pbr), and *Dickeya solani* (Dsol).

A temperature response model based on the cardinal temperatures (minimum, maximum, and optimum for the process response) was fitted to final lesion sizes in each dataset (Fig. 1). This provided four strain-specific sets of parameters for the model.

The temperature response was unimodal for all four isolates and showed clear differences among species and strains. The overall model fit was satisfactory with a NRMSE (normalised root mean square error) of 18.9%.

The model was then used together with the climate change data to project the future risk of crop damage due to blackleg in Eastern Scotland. Our research questions were: (1) How will the risks posed by Pba, the main cause of potato blackleg in Scotland, change in the future? (2) Is there potential for a climate-change induced shift in the prevalence of blackleg-causing species / strains in Scotland?

Projected risk of blackleg for the 2030s and 2080s

Projections suggest that as the weather in Scotland changes, the increase in temperature will result in increased risk of crop damage due to Pba (Fig. 2). Pba risk increased consistently with time and CO₂ emissions. Smaller increases in risk were projected for the warmer summer months as temperatures are currently near the optimum for blackleg.

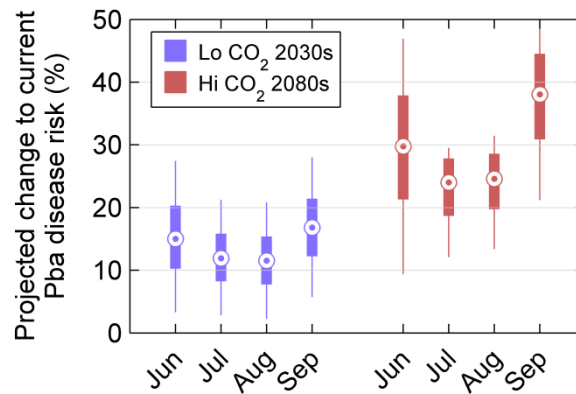


Fig. 2. Projected change in blackleg risk in Eastern Scotland for two future emissions scenarios. Boxplots show uncertainty due to internal climate variation, and projected values are expressed relative to the 1961-1991 baseline climatology to show the percentage change to current risk levels. Boxes extend from first to third quartile, medians are marked in each box, and whiskers extend to the 5th and 95th percentiles.

Projected competition among blackleg-causing strains

The competitive advantage of an isolate under future climates is indicated by the ratio of their projected lesion sizes. Projections suggest that in Scotland in the future Pba will have a competitive advantage over the other three isolates tested (Fig. 3). This was expected as monthly average temperatures seldom exceeded 20 degrees in the climate change datasets, indicating that Pba will produce the largest lesions (Fig. 1). The difference in lesion size was least pronounced in the hotter summer months, and declined with time and CO₂ emissions as temperatures increased and lesion sizes converged (Fig. 1).

4. Policy implications

The above findings have important implications for current and future potato seed production in Scotland, having a continued and potentially growing impact on downgrades and failures during the crop inspection, which reached almost 9% in 2012. While this is high, it still compares favourably to losses in the Netherlands, who experienced losses of 15% in 2015 (3% in Scotland for the same period - SASA) (Appendix 1). Scotland has seen an increasing trend in seed sales to non-EU countries for at least 15 years, with record levels of seed exports last season. It is therefore imperative that Scottish seed remains of high quality and blackleg, as by far the main fault in seed production, is kept under control. A priority now is to gather quantitative information on the processes underlying the establishment and spread of blackleg, in order to improve our understanding of the epidemiology of this disease in order to find novel control measures to reduced disease incidence. This may necessitate a revised strategy for collecting and recording information for crops containing blackleg during the crop inspection.

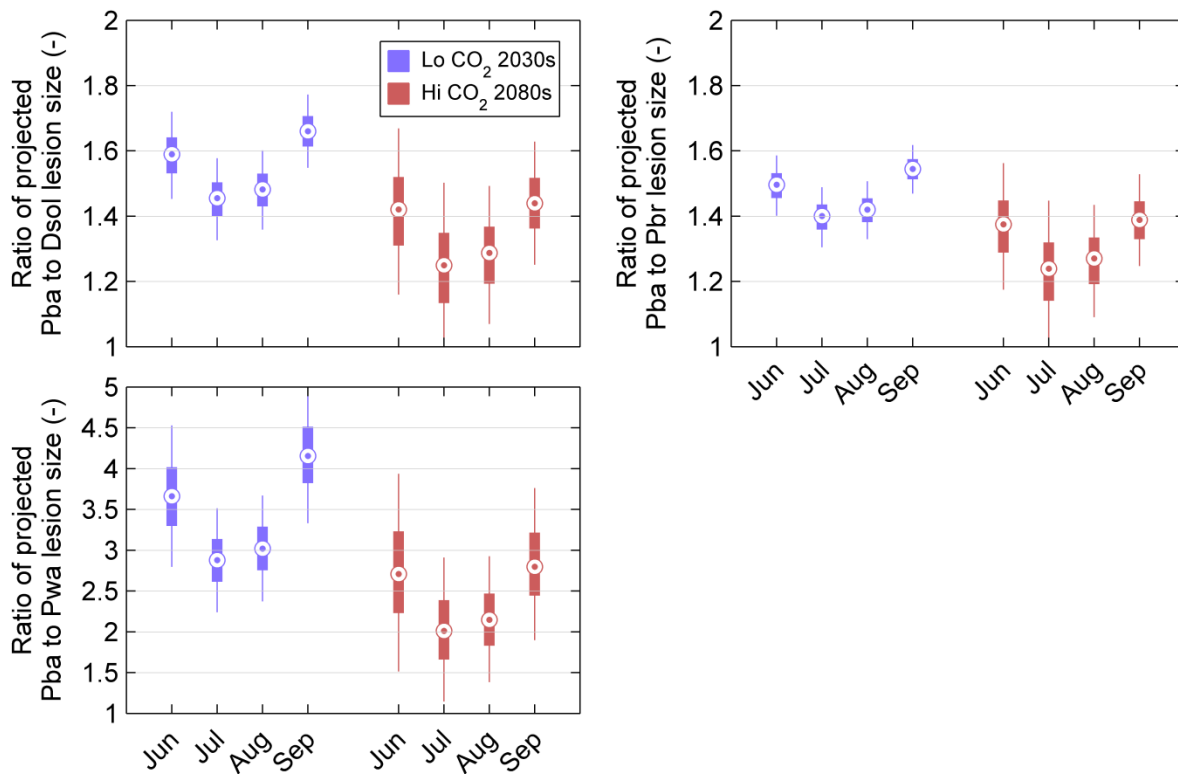


Fig. 3. Ratio of projected lesion sizes between different species under climate change in Scotland. Boxplots show uncertainty due to internal climate variation, and projected values are expressed relative to the 1961-1991 baseline climatology to show the percentage change to current risk levels. Boxes extend from first to third quartile, medians are marked in each box, and whiskers extend to the 5th and 95th percentiles.

5. References

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6. Further information

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Appendix 1

BLACKLEG, SEED POTATOES - NETHERLANDS: SPECIES SHIFT

A ProMED-mail post

<<http://www.promedmail.org>>

ProMED-mail is a program of the

International Society for Infectious Diseases <<http://www.isid.org>>

Date: Wed 27 Jan 2016

Source: Farmers Weekly [edited]

<<http://www.fwi.co.uk/arable/new-bacteria-main-cause-of-blackleg-in-dutch-seed-potatoes.htm>>

New bacteria main cause of blackleg in Dutch seed potatoes

Test results have confirmed a major shift in the bacterial species causing blackleg in Dutch seed potatoes, with a new species being found in two-thirds of seed crops investigated. This seed-borne disease is the focus of inspections of seed crops, some of which are exported to countries such as the UK.

Back in 2014, researchers reported the first case of blackleg being caused by *Pectobacterium carotovorum* subsp *brasiliensis* [Pcb] in the Netherlands [see link below]. Of all bacterial diseased plants the Dutch General Inspection Service (NAK) for seed investigated in 2015, 67 per cent were found to have this strain.

Before 2014, *Dickeya* species dominated, but last year [2015], they were found in 21 per cent of the diseased plants. The species *Pectobacterium atrosepticum* and *Pectobacterium wasabiae* were each found in about 6 per cent.

In addition to the shifting species, NAK says 2015 saw an increase in the area downgraded because of blackleg to 15 per cent of seed potato fields, the highest percentage in 4 years.

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