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Where Do We Go After Smith?

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SUMMARY

In Britain growers rely on 'Smith Periods' to predict the occurrence of potato late blight; one of the most destructive plant diseases world-wide. A Smith Period describes a set of environmental conditions during which disease is able to develop. These conditions were, however, defined from field observations in the 1950s and current evidence suggests that the criteria should be updated to provide a better predictor of blight. The Smith Period is also limited in that it uses historical (recent) weather data and is location-specific, i.e., it does not account for disease pressure in surrounding regions. We aim to develop more accurate and comprehensive methods of assessing blight risk. Predictions will be based on the properties of the contemporary pathogen population that consolidates the current epidemiological understanding of the disease, weather forecast data, and sophisticated models that predict risk of spatial spread at the landscape-scale.

KEYWORDS

Phytophthora infestans, late blight, epidemic, dispersal, landscape, risk, simulation, decision support system

BACKGROUND

The Smith Period has been the mainstay of potato late blight forecasting in the UK since 1975. The Smith rule is currently used in a slightly modified version compared to the original rule (Chapman, 2012): a full Smith Period has occurred if, on each of 2 consecutive days: the minimum air temperature was at least 10°, and there were a minimum of 11 hours with a relative humidity of at least 90%. Within the calculation there is a provision for a 'near miss'. This occurs when the temperature criterion has been satisfied but the number of hours with a high relative humidity totaled only 10 hours on one or both days. Smith Period data are provided free of charge as a collaborative service (http://www.blightwatch.co.uk/) supported by the Potato Council and industry sponsors that covers the whole of the UK down to individual postcode level (a broad subdivision of the UK into approximately 125 geographic regions). It's a robust prediction model that has served the industry well for decades, but there is mounting evidence that the temperature and humidity thresholds need to be updated to match the newer, more aggressive strains of the pathogen that we now have in Britain (Chapman, 2012, Cooke *et al.*, 2012). The potato industry in the UK also benefits from another Potato Council funded source of blight risk data: disease outbreaks are reported by scouts as part of the 'Fight Against Blight' campaign (http://www.potato.org.uk/fight-against-blight). This provides valuable confirmation of blight activity, but it is clear that not every outbreak is reported. Critically, neither source of blight risk data accounts for disease build up nor pathogen dispersal at wider spatial scales than the individual infected crops, and neither consider prognosis for future infection and spread of disease. Here, we set out to develop a more comprehensive disease forecasting system that provides the UK potato industry with information on the historical, current, and future risk of disease.

PROPOSED METHODOLOGY

Environmental parameters

The precise relationship between humidity, temperature, and infection will be examined using current cultivars and a representative selection of isolates for the contemporary *P. infestans* population. The experiments will be conducted in growth chambers set at a range of temperatures with different controlled periods of high humidity. This will provide data to refine the Smith Period criteria, resulting in a dynamic set of decision rules that changes with the genetic make-up of the UK pathogen population. The new Smith criteria will be used to parameterize a sophisticated, spatiotemporal simulation model of the potato late blight pathosystem for UK weather conditions (Skelsey *et al.*, 2005, Skelsey *et al.*, 2009b, Skelsey *et al.*, 2009c, Skelsey *et al.*, 2010); they will define when conditions are conducive for infection, and when they are not.

Model validation

Historical weather and late blight outbreak data (from the Fight Against Blight campaign) will be used to provide a 'real-world' validation of new Smith Period criteria and allow the project team to beta-test model prototypes and fully understand the requirements of industry users. These data will also be combined with historical records on the spatial coverage of potato production areas in the UK to provide a unique landscape-scale validation of the potato late blight pathosystem simulator. The process of model parameterization and validation is illustrated below, using Scotland as an example (Figure 1a).

A SPATIALLY EXPLICIT DECISION SUPPORT SYSTEM

The late blight pathosystem simulator (with the new Smith Period criteria as a component) can produce a wide variety of output pertaining to historical, current, and future risk of disease occurrence and epidemic spread. The following predictors of risk were highlighted as being particularly useful during knowledge exchange events within the potato industry.

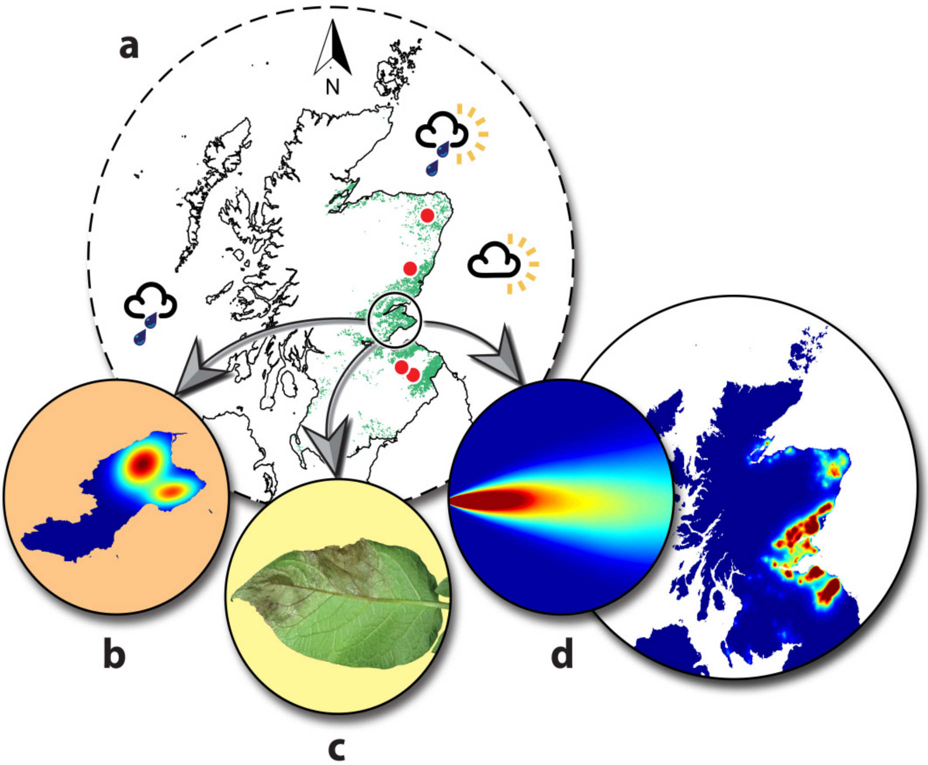

Figure 1. *A spatially explicit decision support system for potato late blight.* ***a)*** *Historical weather, outbreak (red circles), and crop distribution data (green areas show potato crops in Scotland in 2012) will be used to refine and test new Smith Period criteria, which will be implemented within an existing late blight pathosystem simulator. Simulator output:* ***b)*** *historical risk of late blight activity in an example geographic region (red areas are high risk);* ***c)*** *risk of disease occurrence for any given area according to new Smith Period criteria, using either current weather observations or weather forecast data; and* ***d)*** *future risk of viable spore transport over distance for any given area assuming a hypothetical inoculum source, or the cumulative inoculum risk from all known reported outbreaks of disease*

Historical risk of blight activity: primary inoculum risk

The simulator can quantify and map the connectivity of potato fields for the spread of disease for any specific geographic region and time period (Figure 1b). If the distribution of crops and weather data from the previous growing season is used, a map highlighting the high risk areas for primary inoculum in the upcoming season is obtained (assuming that last year's hot-spots for late blight are next year's hot-spots for primary inoculum). This could be useful for adjusting volunteer plant control strategies or fungicide plans. If this analysis is repeated using many years of weather and crop rotation data, we may find a long-term geographic trend in blight activity, which could serve as a map of expected blight risk for the whole upcoming season, and beyond. This could be useful for making longer-term strategic decisions about varietal or product choices.

Current / future risk of disease occurrence

During the season the simulator can quantify and map the current risk of disease occurrence according to the new Smith Period criteria (Figure 1c). We can use weather data from the previous 48 hours (current practice), or from various upcoming meteorological 'lead times' (e.g., 1-day, 2-day forecast) in order to provide the industry with advanced warning of conducive conditions for blight, affording greater time to act.

Risk of inoculum dispersal among fields

The late blight pathosystem simulator has an aerobiological component that is used to determine the spread of disease between fields (Skelsey *et al.*, 2008, Skelsey *et al.*, 2009a). This has proven to be a useful tool for modifying spray recommendations (Kessel *et al.*, 2009, Kessel *et al.*, 2012, Skelsey *et al.*, 2009a); i.e., even if a Smith Period is predicted, growers may not be at risk if viable spores cannot travel very far. The distance that spores can travel is dependent on wind speed and atmospheric turbulence, and detached sporangia are sensitive to the dose of UV radiation received during transportation. The simulator can therefore predict the average distance that viable spores will travel using weather forecast data for any specific area, and predict actual spore deposition patterns from known outbreaks of disease (Figure 1d).

CONCLUSIONS

This modeling framework will constitute the first spatially explicit decision support system to provide a daily forecast for the risk of disease spread for any crop pathosystem. These maps and model output, or the model itself (as an interactive tool for subscribers), would be ideal for publication on the blightwatch.co.uk website. This will provide a further striking visual aid to decision making, and facilitate knowledge transfer in a manner meaningful to the industry. We will continue to work closely with the industry and the Potato Council to ensure we develop methods that are relevant and applicable to day-to-day management decisions and are appropriate for implementation on a GB scale.

REFERENCES

Chapman, A.C. 2012. The changing *Phytophthora infestans* population: implications for late blight epidemics and control. Ph.D. Thesis, University of Dundee. pp. 275.

Cooke, D.E.L., Cano, L.M., Raffaele, S., Bain, R.A., Cooke, L.R., Etherington, G.J., Deahl, K.L., Farrer, R.A., Gilroy, E.M., Goss, E.M., Grunwald, N.J., Hein, I., MacLean, D., McNicol, J.W., Randall, E., Oliva, R.F., Pel, M.A., Shaw, D.S., Squires, J.N., Taylor, M.C., Vleeshouwers, V.G.A.A., Birch, P.R.J., Lees, A.K., and Kamoun, S. 2012. Genome analyses of an aggressive and invasive lineage of the Irish potato famine pathogen. Plos Pathogens 8(10).

Kessel, G.J.T., Evenhuis, A., van den Bosch, G.B.M., Hoekzema, G.A., Bosman, L., Topper, C.G., Esselink, L.J., van Gent-Peltzer, M.P.E., van der Lee, T.A.J., and Schepers, H.T.A.M. 2012. An IPM 2.0 control strategy for potato late blight based on cultivar resistance and monitoring of virulence in the local *P. infestans* population. Pages 87-92 in: H.T.A.M. Schepers, ed., Proceedings of the Thirteenth EuroBlight Workshop, St. Petersburg, Russia. PPO-Special Report no. 15. pp. 260.

Kessel, G.J.T., Skelsey, P., Holtslag, A.A.M., Moene, A.F., and van der Werf, W. 2009. Regional spore dispersal as a factor in disease risk warnings for potato late blight: a proof of concept. Pages 91-96 in: H.T.A.M. Schepers, ed., Proceedings of the Eleventh EuroBlight Workshop, Hamar, Norway. PPO-Special Report no. 13. pp. 320.

Skelsey, P., Holtslag, A.A.M., and van der Werf, W. 2008. Development and validation of a quasi-Gaussian plume model for the transport of botanical spores. Agricultural and Forest Meteorology 148(8-9):1383-1394.

Skelsey, P., Kessel, G.J.T., Holtslag, A.A.M., Moene, A.F., and van der Werf, W. 2009a. Regional spore dispersal as a factor in disease risk warnings for potato late blight: a proof of concept. Agricultural and Forest Meteorology 149(3-4):419-430.

Skelsey, P., Kessel, G.J.T., Rossing, W.A.H., and van der Werf, W. 2009b. Parameterization and evaluation of a spatiotemporal model of the potato late blight pathosystem. Phytopathology 99(3):290-300.

Skelsey, P., Rossing, W.A.H., Kessel, G.J.T., Powell, J., and van der Werf, W. 2005. Influence of host diversity on development of epidemics: an evaluation and elaboration of mixture theory. Phytopathology 95(4):328-38.

Skelsey, P., Rossing, W.A.H., Kessel, G.J.T., and van der Werf, W. 2010. Invasion of *Phytophthora infestans* at the landscape level: how do spatial scale and weather modulate the consequences of spatial heterogeneity in host resistance? Phytopathology 100(11):1146-61.

Skelsey, P., Rossing, W.A.H., Kessel, G.J.T., and van der Werf, W. 2009c. Scenario approach for assessing the utility of dispersal information in decision support for aerially spread plant pathogens, applied to *Phytophthora infestans*. Phytopathology 99(7):887-95.