How to use airborne inoculum spore traps to improve current late blight management strategies ?

Alain Decroës[1], Vivien Le Vourch[1], Charlotte Liénard[1], Cyril Van Steenberge[2], Damien Rosillon[2], Pierre Lebrun[3], Vincent Cesar[2] and Anne Legrève[1]

UCLouvain
Earth and Life Institute

[1] UCLouvain, Earth & Life Institute, Applied Microbiology – Phytopathology, Croix du Sud 2 bte L7.05.03, B-1348 Louvain-la-Neuve, Belgium
[2] Centre wallon de Recherches agronomiques (CRA-W), Libramont, Belgium
[3] Filière Wallonne de la pomme de terre (FIWAP asbl), Gembloux, Belgium

Context

Potato late blight, a serious plant disease caused by *Phytophthora infestans*, is one of the main reason of pesticides use in Wallonia, Belgium (SPW, 2020). Mathematical models to predict the risk of potato late blight development in the field have been valued in the management of this disease for almost a century (Arora *et al.*, 2014). Despite the development of various model-based Decision Support Systems (DSS) in major potato-producing countries, none of them exploit airborne inoculum to determine the risk of infection. Quantification of airborne inoculum has been used for decades to understand the epidemiology of major plant diseases (Heyden *et al.*, 2021) and there is a renewed interest in using this kind of data to improve late blight management (Fall *et al.*, 2015, Lees *et al.*, 2019, Arocha Rosete *et al.*, 2021). Comparison between airborne inoculum detection and recommendations given by DSS could help to delay first fungicide applications in fields, in the absence of primary inoculum. In this work, the relationships between meteorological parameters, airborne inoculum and observations of late blight symptoms are assessed in the field. The potential of using aerobiological data to improve current DSS in Wallonia is being evaluated.

Research questions

Is it possible to use near-real-time airborne inoculum quantification data of *Phytophthora infestans* to improve modelling of late blight epidemics in the fields? Is it possible to predict the presence of airborne inoculum from meteorological data?

Results for 2019-21

Weather conditions in Belgium during the 2019-21 growing seasons

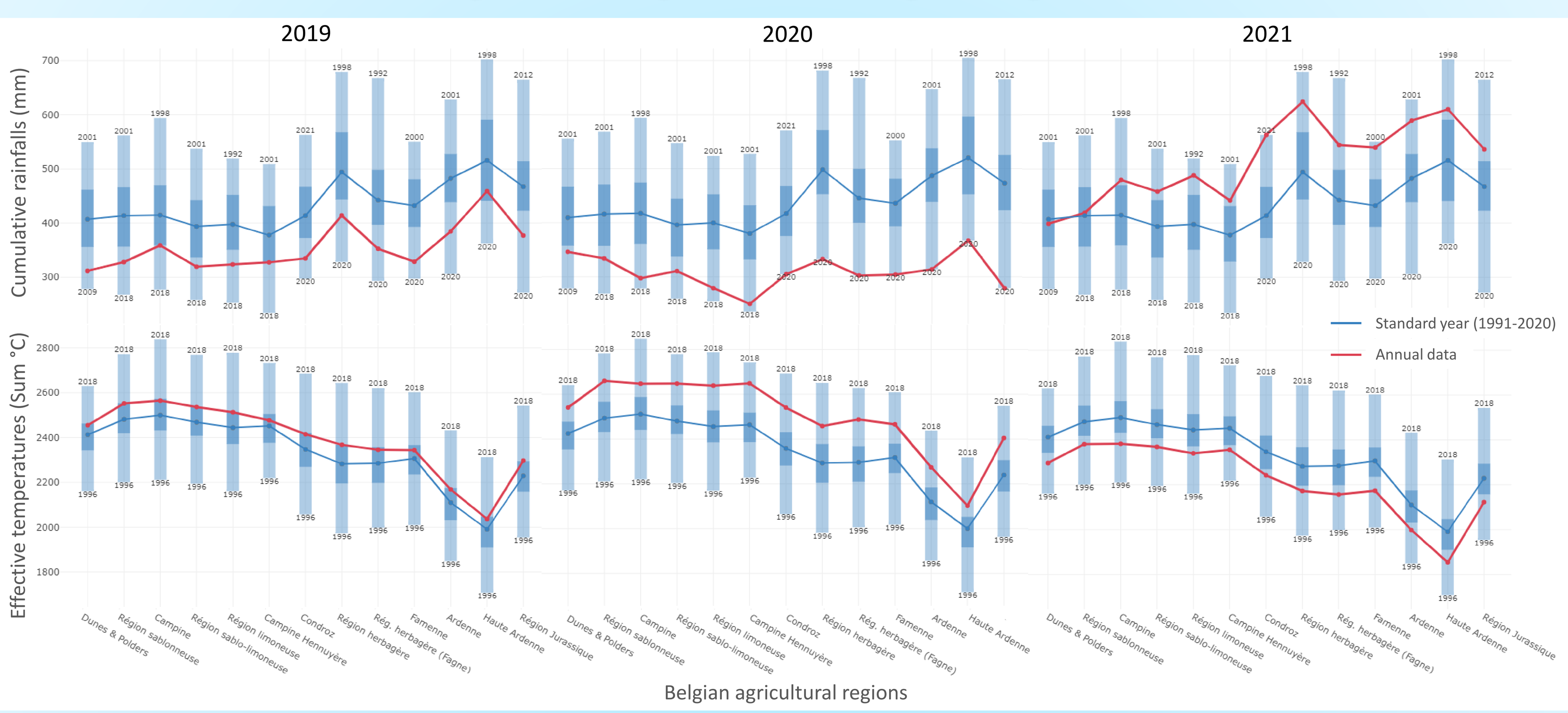


Figure 2. Summary of rainfall and temperature during three consecutive potato growing seasons (2019-2021, red lines) in Belgium compared to a "standard year" (blue lines). Blue boxes show extreme values and quantiles 1 & 3. Data provided by Agromet (CRA-W) and IRM.

➔ The 2019 and 2020 potato growing seasons were hot and dry in all Belgian regions, which is not suitable for the development of *P. infestans*. In contrast, 2021 was cooler than seasonal norms and particularly wet.

Late blight risk periods do not necessarily correspond to the presence of airborne inoculum

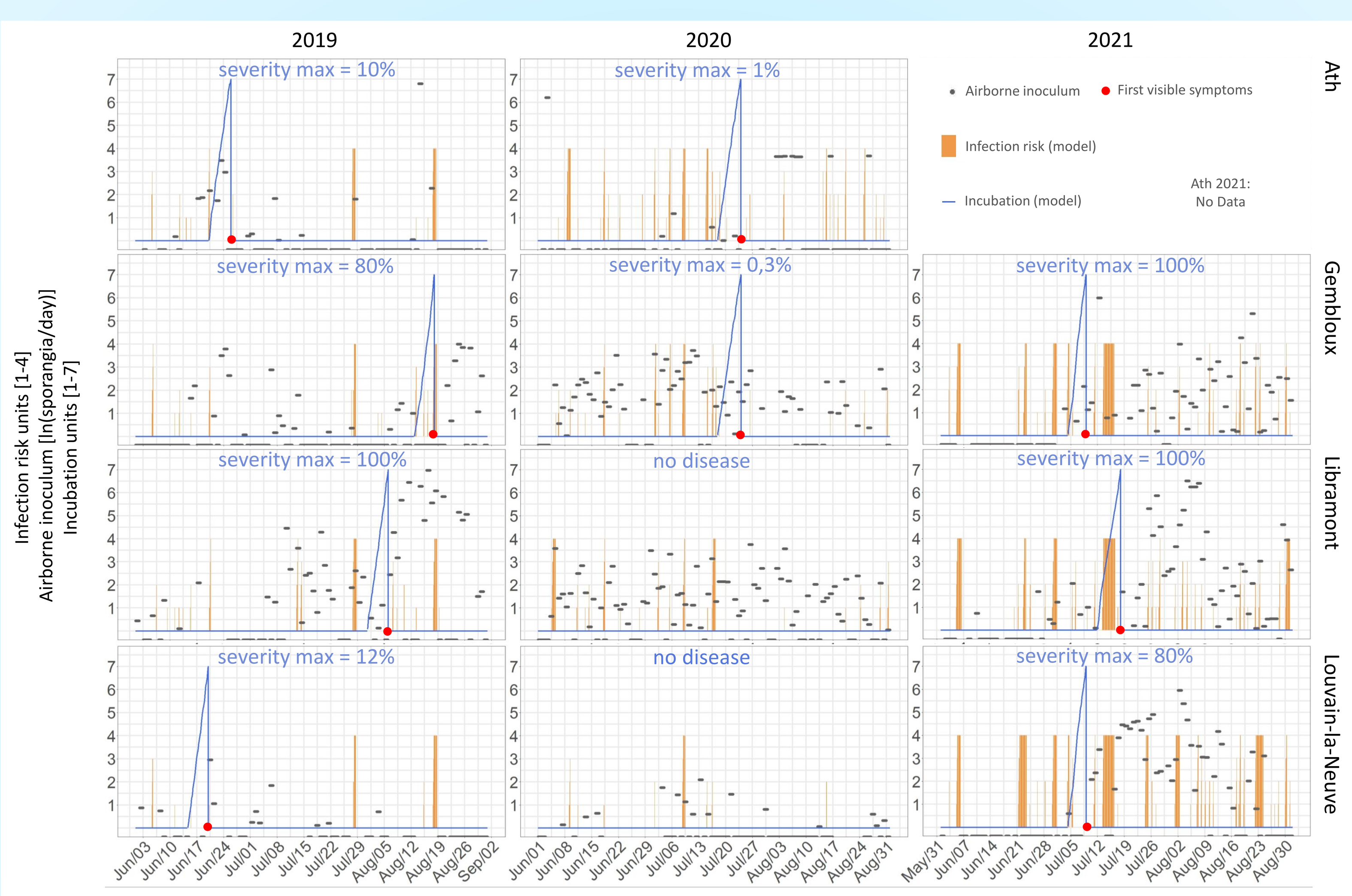


Figure 3. Relationship between *P. infestans* airborne inoculum concentrations, first symptoms observation, late blight infection risk and incubation period modeled by Guntz-Divoux.

➔Disease pressure was high in 2021, weak in 2019 and nearly inexistent in 2020.
➔The outbreak of the first symptoms almost always preceded the detection of airborne inoculum along with a period during which temperature and humidity conditions were appropriate.
➔The onset of the epidemic is correlated with an increase in airborne inoculum. However, in some cases, *P. infestans* airborne inoculum was also detected when no disease was observed.
➔In some cases, favourable periods (i.e. concordance of a high risk of late blight and the detection of airborne inoculum) were not followed by the onset of the disease.

Catching the inoculum in field trials

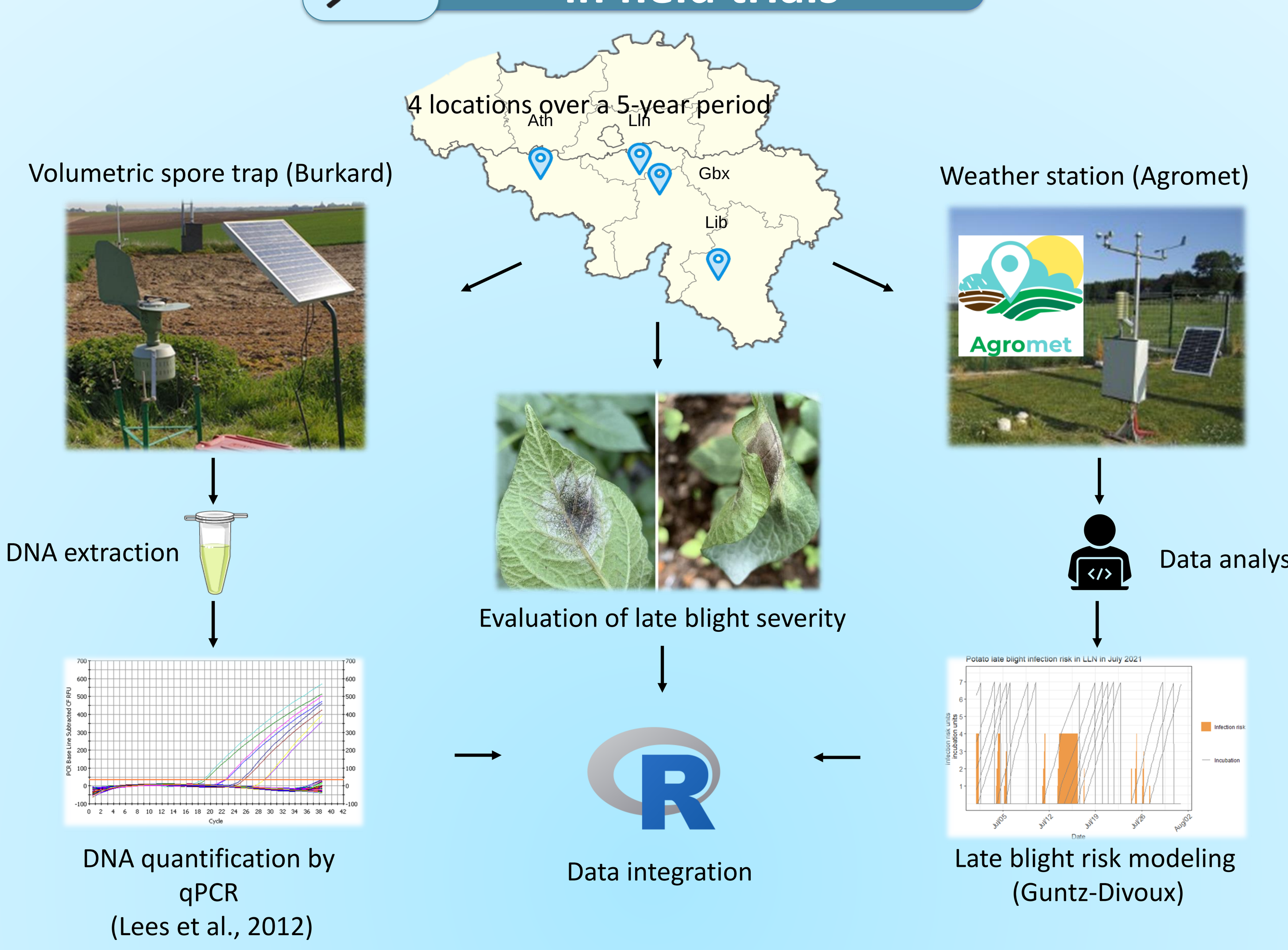


Figure 1. Diagram of the experimental strategy adopted in the PotatoSmart project.

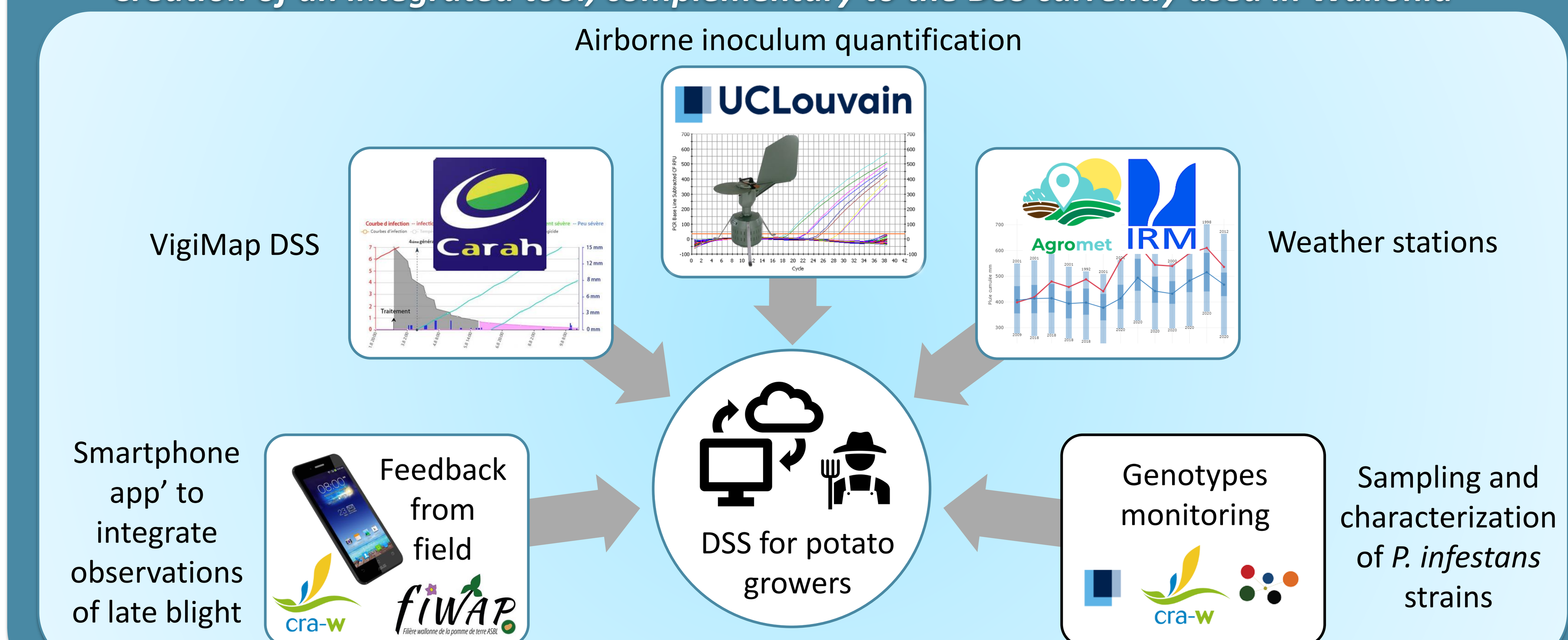
Twelve field assays were conducted between 2019 and 2021 in four locations (Ath, Gembloux, Libramont, Louvain-la-Neuve) in Belgium with potato varieties susceptible to late blight. No fungicide protection, irrigation or *P. infestans* inoculation was applied. During these trials, meteorological data were recorded at the plot level and the severity of late blight was monitored over the season. Airborne particles of *P. infestans* were collected continuously using a Burkard spore trap with 7-day recording (Burkard Manufacturing Co. Ltd, Rickmansworth, Hertfordshire, UK). The spores traps were placed near the trials, 1 meter above the ground level and the vacuum flow was regulated at 10 liters per minute. Airborne particles were collected on wax-coated Melinex tape glued to a rotating drum, with a 7-day cycle. (Burkard Manufacturing Co. Ltd) (345 mm × 20 mm). Each week, the tape was cut into seven daily segments of 48 × 20 mm. DNA of material collected on daily segments was extracted using phenol-chloroform protocol, adapted from the method described in Duvivier *et al*. (2013). *P. infestans* was then quantified by quantitative PCR with primers and a Taqman probe specific to *P. infestans* (Lees *et al.*, 2013). A calibration curve was established with dilutions of sporangia extracted under the same conditions and used to convert the cq value into sporangia-equivalent values. Relationships between airborne inoculum and the risk of late blight estimated with the Guntz-Divoux model were then evaluated in connection with the severity observed in the field. In addition, the outputs of the warning system Vigimap (CARAH) were also analyzed in relation to the collected data.

What's next ?

Further field data collection and integration

➔The 2019 & 2020 growing seasons were not favourable for late blight development. Additional field trials are planned for the next two growing seasons to supplement the existing data, representing contrasting disease pressures.
➔The systematic comparison of the meteorological parameters leading or not to symptoms onset in the presence of primary inoculum will help to inform disease risk forecasting.
➔Cross correlations will be conducted in order to evaluate whether meteorological data could also be useful to forecast the concentration of airborne inoculum.
➔The genotyping and characterization of the *P. infestans* present in the field trials will help to further interpret the results.

Creation of an integrated tool, complementary to the DSS currently used in Wallonia



References:
Arocha Rosete, Y., To, H., Evans, M., White, K., Saleh, M., Trueman, C., ... & Scott, J. A. (2021). Assessing the Use of DNA Detection Platforms Combined With Passive Wind-Powered Spore Traps for Early Surveillance of Potato and Tomato Late Blight in Canada. Plant Disease, PDIS-12.
Arora, R. K., Sharma, S., & Singh, B. P. (2014). Late blight disease of potato and its management. Potato J, 41(1), 16-40.
Fall, M. L., Van der Heyden, H., Brodeur, L., Leclerc, Y., Moreau, G., & Carisse, O. (2015). Spatiotemporal variation in airborne sporangia of P hytophthora infestans: characterization and initiatives towards improving potato late blight risk estimation. Plant Pathology, 64(1), 178-190.
Iglesias, I., Escuredo, O., Seijo, C., & Méndez, J. (2010). Phytophthora infestans prediction for a potato crop. American journal of potato research, 87(1), 32-40.
Lees, A. K., Roberts, D. M., Lynott, J., Sullivan, L., & Brierley, J. L. (2019). Real-time PCR and LAMP assays for the detection of spores of Alternaria solani and sporangia of *Phytophthora infestans* to inform disease risk forecasting. Plant disease, 103(12), 3172-3180.
SPW (2020). Utilisation des produits phytopharmaceutiques. Available on http://etat.environnement.wallonie.be/contents/indicatorsheets/AGRI%206.html.

Acknowledgements: This research project is funded by the Service public de Wallonie.