CRP FELLOWSHIP SUMMARY REPORT

Name:	Peter Ojiambo
Subject:	Modelling impact of aerial and trade dispersal on transmission of plant pathogens in networks
Theme:	Managing Risks in a Connected World (Theme II)
Host Institution:	NIAB East Malling Research, United Kingdom
Host Supervisor:	Prof. Xiangming Xu
Date:	May 15, 2022 to November 15, 2022 (6 months)

Consent is hereby granted to OECD to publish this summary report on the Co-operative Research Program's website.

1. What were the objectives of the research project? Why is the research project important?
Pathogen dispersal is key in development of plant disease epidemics at different spatial scales, ranging from a field to the landscape level. Currently, inferred networks are used to determine the risk of transmission and disease spread for aerially dispersed pathogens. However, these network models do not account for either disease intensity, or determine the importance of implementing within-node (e.g., fungicide, rouging) and between-node (e.g., quarantine, isolation reducing trade) on treatment on pathogen transmission and disease spread. We proposed an analytical framework to account for disease incidence at a node, using two kernel functions based on trade links (or connectivity between nodes) and those based on distance (e.g., power-law functions) and these were evaluated using different types of disease networks (e.g., random, scale-free and small-world) relevant in disease epidemiology. This modeling approach should provide a general framework to better assess the risk of long-distance spread of invasive species in agricultural and forest systems and addressed the following objectives: i) Determine the relative effectiveness of reducing the levels of infectious disease compared to reducing connectivity of a specific node, ii) Establish the effect of adding trade network (and their properties) to the distance-based network on disease spread and management for different types of networks and iii) Determine the relative importance of within-node and between node treatment on the dispersal and spread of disease within networks.

Development of simple risk assessment tools to help policy makers and managers of agricultural systems make informed decisions to avoid and react to biosecurity and understanding the global spread of invasive species, early detection and assessment to develop appropriate policy response are two key objectives of this theme. The proposed work will lead to a better assessment of risk of disease spread and provide a framework to help policy makers identify areas where resources are most needed for efficient disease monitoring. Further, this prediction system will also facilitate early detection of disease spread and foster application of disease management strategies such as chemical control based on risk of disease occurrence.

2. Were the objectives of the fellowship achieved?
Or are they on the way to being achieved? If not, for what reasons? (The data or research is still ongoing or being analysed; technical reasons (e.g. equipment not working, adverse weather conditions, unexpected results, etc.; other reasons?)
Most of the work involved in the initial formulation and testing of the model was achieved during the fellowship period. Model formulation involved the details of a static and dynamic version of the model. The dynamic version model was developed as a compartment model that accounts for susceptible, infected and removed (SIR) nodes within the network. Specific variables and parameters were developed to explain and calculate the rates of transmission between different compartments of the model. Aspects to within-node infection dynamics and between-node spread were developed and tested including details on detection and control within a node. The networks of interested (random, scale-free and small-world) were generated to have different sizes and connectivity to allow in establishing the impact of size and degree connectivity on disease control and spread. The final stage of model development involved parameterization of the model to identify default parameters that will be used in the simulation runs to provide answers to the research objectives. The process is time-consuming and requires use of high computing facilities to run the simulations. We have just completed the identification of default values for all parameters and formal model simulation runs will start within next few weeks.

3. What were the major achievements of the fellowship? (up to three)

1. One of the main objectives achieved during the fellowship period was the conceptualization and parameterization of the model to facilitate our understanding of how aerial and trade dispersal interplay with connect work connectivity to influence pathogen transmission and disease spread. Currently, there are no models that integrate aerial and trade dispersal within a network framework to understand disease spread. Most of the available models examine these two aspects of disease spread within independent frameworks to address issues related to risk assessment, sampling and impact of treatment and containment on mitigating epidemic spread. Our simulations show that with all factors being constant, dispersal of the pathogen through trade contributes more disease spread than dispersal of the pathogen through the air.
2. A second objective achieved during the fellowship period was to analytically establish how different treatment options of affected sites within the network could influence disease dynamics. More specifically, we examined treating sites (e.g., using fungicides or rouging of infected plants) following detection influenced disease dynamics.
3. The fellowship period allowed for the establishment of a long-term collaboration with my host at NIAB-EMR and at University of Cambridge, to explore opportunities for application of grants for collaborative research projects.

4. Will there be any follow-up work?

We are in the process of initiating model simulation runs to i) Determine the relative effectiveness of reducing the levels of infectious disease compared to reducing connectivity of a specific node, ii) Establish the effect of adding trade network (and their properties) to the distance-based network on disease spread and management for different types of networks and iii) Determine the relative importance of within-node and between node treatment on the dispersal and spread of disease within networks. We envision to submit one article to *Ecography* and presenting the paper at 2023 International Epidemiology Workshop in France.

5. How might the results of your research project be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

The proposed research is cross-cutting across several disciplines, including plant pathology, ecology, population biology, statistics, and epidemiology. Outcomes from this project will benefit both researchers and scientists in improving monitoring and surveillance of disease outbreaks for better management of resultant epidemics. The findings should also lead to more targeted application of disease control measures (e.g., fungicides) and tailoring disease monitoring resources to areas that are important in risk of disease transmission and spread.

6. How was this research relevant to: The objectives of the CRP? The CRP research theme?

The research project is strongly aligned to problems outlined in Theme II (Managing Risks in a Connected World). Development of simple risk assessment tools to help policy makers and managers of agricultural systems make informed decisions to avoid and react to biosecurity and understanding the global spread of invasive species, early detection and assessment to develop appropriate policy response are two key objectives of this theme. This project will lead to a better assessment of risk of disease spread and provide a framework to help policy makers identify areas where resources are most needed for efficient disease monitoring. Further, this prediction system

will also facilitate early detection of disease spread and foster application of disease management strategies such as chemical control based on risk of disease occurrence.

7. Satisfaction

The fellowship greatly enhanced my professional where I did learning a new statistical programing language while working on my project. I also enhanced my previous network which was expanded potential collaborators in Europe. I was extremely satisfied with the CRP fellowship and would consider applying for another opportunity in the new future.

8. Advertising the Co-operative Research Programme

I did learn about the fellowship through my host who was a previous recipient of the fellowship. In this regard, I have reached out to my peers who plan to undertake a study leave and informed them about this fellowship opportunity as well. OECD should consider sponsoring select research or conference meetings and have a booth at the venue where participants can learn more about available fellowships.