Predicting African insect crop pests in real-time (Ref IAP2-18-14)

Centre for Ecology & Hydrology (CEH)

In partnership with University of Glasgow/CABI

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Overview

Crop pests are of serious and growing concern throughout Africa, causing significant economic and dietary impacts on humans and livestock. Each year farmers face a regular but unpredictable onslaught from a wide range of plant pests, most notably from insects that have recently reached the continent such as the Fall armyworm (*Spodoptera frugiperda*) (see Figure 1), or the Tomato leafminer (*Tuta absoluta*). The larvae of these species cause major yield loss in staple crops when their abundance peaks. The unpredictability of these peaks has negative impacts on farmer livelihoods and exacerbates poverty issues. Therefore, predicting such peaks in abundance in real-time will help farmers plan cropping and advise when to use pest control measures and mitigate the problems.

The central aim of this project is to develop state-of-the-art mathematical models, underpinned by real-time surveillance and environmental data from the CABI-led project Pest Risk Information Service (PRISE), for a number of key African pest species to enable real-time predictions of abundance. This information will be deployed to the farmers on the ground using the PRISE and Plantwise dissemination network.

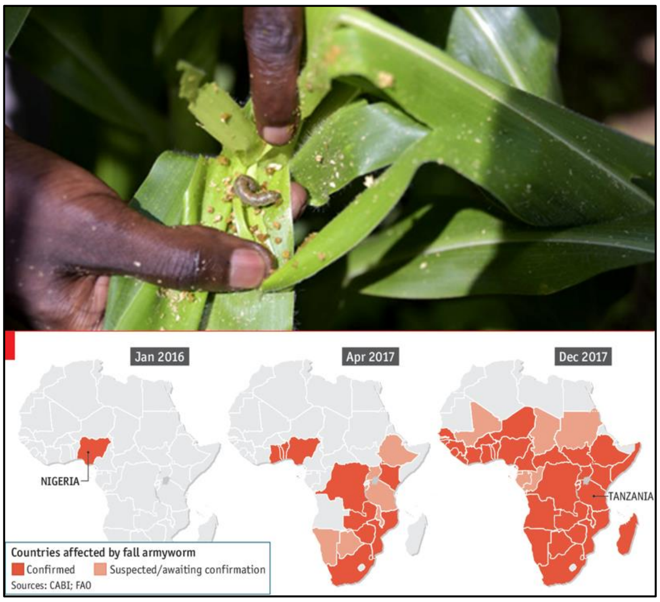

Figure 1: Image of a Fall armyworm, *Spodoptera frugiperda*, and it's invasion in Africa.

Methodology

Environmental and land use variation makes predicting insect species abundance difficult. For example, temperature variation has complex non-linear effects on species development and demographics at various developmental stages. Larval development time in the Fall armyworm can vary by as much as 2 weeks and pupae can remain in the ground for a week to over a month. However, the supervisor team have been developing state-of-the-art stage-structured delaydifferential equation models to predict insect species abundance in fluctuating environments. A major component of this approach is incorporating environmental drivers in each developmental stage and life-history process of the modelled species. Thus, using remotely sensed environmental data pertinent to the species we will be able to predict abundance across a wide range of geographical locations.

The student will largely interact and benefit from the PRISE project, funded by the UK Space Agency and led by CABI. PRISE is a 5-year project aiming to improve the livelihoods of smallholder farmers by reducing crop losses caused by pests across six sub-Saharan African countries. Towards that aim, PRISE will forecast the phenological risk of pest outbreaks for sub-Saharan Africa, using a novel combination of earth observation technology, satellite positioning, and plant-pest lifecycle data. Expansive, novel crowd sourcing observations will also be established to strengthen and validate the system. Thus, thanks to PRISE, the student will have access to the environmental data from Earth Observation validated by the consortium (e.g. land surface temperature and rainfall), pest phenology data across three different countries (Kenya, Zambia and Ghana) and crowdsourced observations. Validating the student's stage-structured model against this real-time data ensures accuracy and usefulness. Moreover, the population models developed in this project will build upon the existing phenological models already in use within PRISE, with the main aim of improving accuracy.

Although we expect most of the data required for this PhD project is already in hand or expected to be collected, there is the possibility for the student to carry out field work in Africa to collect any missing crucial data for the models (e.g. life-history parameters). CABI will facilitate this work through this network of centres and research partners in Kenya, Zambia and Ghana.

In this project, the student will:

1. Develop stage-structured mathematical models for a range of plant pest species, including the Fall armyworm.
2. Fit the models using Approximate Bayesian computation (ABC) methods with available datasets provided by CABI and collaborators.
3. Validate the models against real-time abundance data from PRISE.
4. Deploy the model into the PRISE project for real-time predictions used by African farmers on the ground.

Timeline

In Year 1, the student will develop stage-structured population models for the target species. This work will require gathering model parameters through literature searches and estimating environmental trait functional relationships using data already collected by CABI. The student will also collate the environmental and pest data required to validate the models.

In Year 2, the student will use ABC to fit the models to time series data collated in previous years, refining the models throughout the process. If crucial data is required further fieldwork will be planned in collaboration with in-country partners.

In Year 3, the models will be validated using real-time crowdsourced data for the target pests.

In Year 3.5, the student will wrap the models into the PRISE project with potential to incorporate automatic feedback from users for further model validation.

Training & Skills

The student will be trained in a wide range of techniques and subjects, including:

- Mathematical population modelling
- Scientific programming in a suitable language, such as R, Matlab or FORTRAN
- Pest insect ecology
- African agriculture
- Remotely sensed data
- Parallel computing and cluster computing
- Advanced statistical techniques
- End user model deployment
- Geographical Information Systems (GIS).

The student will benefit from spending time at each project partner location, including CABI. The student will also visit CABI centres in Africa to gain understanding of the tasks involved, the pest species, and how current data is collected and used on the ground. There will be opportunities for the student to present their work at a number of national and international conferences and to project partners.

In addition, the student will benefit from transferable skills training from the DTP, CEH and the University of Glasgow. Skills include scientific writing, presentation skills and scientific methodologies (e.g. GIS, Advanced Statistics with R). Knowledge transfer is a key component of this project and the student will have the opportunity to present their work to a wide range of stakeholders including scientists, government agencies, non-profit organisations and farmers.

References & Further Reading

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PRISE https://www.cabi.org/projects/project/62774

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