A CIAT researcher demonstrates how to add a photo to the tumaini app. Photo Credit: Zablon Oyugi

How digital technologies are aiding early pest, disease detection

By Zablon Oyugi

AS climate change intensifies, many countries in sub-Saharan Africa are experiencing surges in pests like fall armyworms, fruit flies, and desert locusts.

According to Benson Ngigi, Stewardship Manager at Agrochemicals Association of Kenya (AAK Grow), warm and humid conditions in these countries create ideal environments for pests to thrive.

The report of a 2020 research on pest and disease control in roots, tubers and bananas (RTB) supported by the Consortium of International Agricultural Research Centres (CGIAR) indicates that 20–40 percent of global crop production are being lost to pests and diseases annually, especially in food-deficit regions with fast-growing populations.

For many producers this warrants the use of pesticides of many kinds to deter the wide variety of pests and insects that can either destroy crops or act as vectors that cause disease. However, the excess use of these chemicals have been found to have not only the potential to harm plants and soil or soil medium but also labourers applying the chemical and in the long run to those consuming the crop.

Early detection is key

Early detection of pests and disease is paramount when operating a medium to large-scale agri-enterprise, as pesticide application can be minimised if pests and diseases are detected before they get out of control.
Abigael Mchana of the Centre for Agriculture and Biosciences International (CABI) says there are numerous digital technologies, ranging from simple applications to complex innovations, that can be used to identify harmful insects, for example.

"Some of the more high-tech tools are quite expensive, especially for farmers in developing countries where weak existing pest and disease surveillance systems have resulted in slow responses to large-scale outbreaks and epidemics," said Ms Mchana during a Horticulture Fair in Naivasha.

"However, as demand and use increases in developed nations such as the United States and in Europe, these tools will become more accessible worldwide."
Digital disease identification tools

Crop disease detection, generally carried out through scouting or field inspections, is often supplemented by diagnostic tools based on serological methods and polymerase chain reaction (PCR) tests.

This process has had its limitations, leading to the development in the past decade of several novel and non-invasive methods which are sensitive, reliable, standardised, high throughput, rapid, and cost-effective.

Remote sensing (RS) methods, coupled with machine learning (ML), are among the emerging approaches that provide

PlantVillage Nuru, a smartphone app. Photo Credit: Zablon Oyugi

reliable and precise technical support for real-time and large-scale crop disease detection and monitoring.

Remote sensing permits the noninvasive measurement of crops' biophysical and biochemical parameters and thus allows for nondestructive monitoring of crop health status.

As a result, various imaging sensors–visible, thermal, multispectral, and hyperspectral–have been studied for crop disease detection.

The applications of these techniques have been gradually developed from novel sensor development, high-throughput image acquisition, processing, and computing, leading to image segmentation and disease classification with algorithm development.

Smartphone image-based disease detection and classification

Given the increased smartphone penetration, one of the mostly used techniques for infield crop disease detection in various African countries is scanning of crops using phone applications.

"CABI has been involved in training farmers especially the youth and women in countries such as Kenya and Uganda through our various programmes on how to download and use specific application developed by our experts to scan crops for disease detections," said Ms Mchana.

The smartphones employ deep learning as an innovative method for image processing and object detection, providing high accuracy in the classification of various crop diseases.

Smartphone-based AI-powered apps could alert farmers and expedite disease diagnosis, potentially preventing or limiting pest and disease outbreaks.

PlantVillage Nuru
For instance, scientists at Penn State University in collaboration with the International Institute of Tropical Agriculture (IITA) created an innovative solution called PlantVillage Nuru. PlantVillage Nuru, an application built by annotating over 200,000 images of diseased cassava plants to train a machine to recognise various diseases and make predictions about a farmer's crop's health in less than one second, has been used to identify symptoms of the cassava mosaic disease (CMD) and other diseases.
With PlantVillage Nuru, an extension worker or farmer can point their phone over a specific cassava leaf, and a box will pop around any areas with symptoms with the diagnosis. In some cases, it will guide the farmer to scan several leaves from different parts of the plant to arrive to a more reliable result.

Once a disease is diagnosed, a farmer can simply push a button to request advice on how to respond. This application has since been extended to other crops such as potato and maize.
Tumaini

Bioversity International and International Center for Tropical Agriculture (CIAT) also developed an AI-powered smartphone app called Tumaini (Kiswahili for hope) in 2019 that is capable of identifying and differentiating symptoms of six banana diseases.

Farmers use the app to upload a photo of an affected crop, which is then scanned for symptoms of pests and diseases using image-recognition technology, drawing on a dataset of more than 50,000 images.

Tumaini records the data, including geographic location, and feeds it into the database. The app then provides a diagnosis and recommends steps to address the affliction.

"The Tumaini app has so far demonstrated a 90% success rate in detecting pests and diseases," said CGIAR in a statement.

Already tested in African countries such as DR Congo and Uganda, the novelty of Tumaini is that it can detect symptoms on any part of the crop – including the fruit, bunch or plant – and can read low-quality images, even those containing background noise, like other plants or leaves, to maximize accuracy.

Drone and satellite image-based disease detection

Advances in drone technology and affordable sensors now allow farmers to collect high-resolution data for detecting crop diseases. By combining aerial images with AI, this technology provides an accurate, efficient method for identifying diseases like late blight in potatoes.
While drones are ideal for detailed monitoring of smaller areas, satellite-based machine learning models can assess general crop health across larger landscapes.
"Drones and AI-powered smartphone sensors can then pinpoint specific issues," said Dan Ng'ong'a, retired Captain running Danico Ventures, which offers drone services to farmers.
He adds that combining high-resolution imagery with advanced algorithms ensures accurate plant health monitoring, improving yields and economic value.

Sequence-based digital surveillance Systems
for pathogens and pests
CGIAR research highlights the growing potential of genetic data to enhance pest and pathogen monitoring. High-throughput sequencing (HTS) technologies are boosting the availability of genetic information, which is crucial for early detection and preventing the spread of harmful strains. Originally applied to plant virus research in crops like sweet potato, HTS has helped identify new viruses and variants in root, tuber and banana (RT&B) crops. This has enabled faster disease detection and the development of specific diagnostic tools.

Stress detection glasses
According to CABI, stress detection glasses are among the most advanced crop pests and disease detection techniques. Stress detection glasses use green light sensitivity to identify plant stress. Healthy plants appear black, while stressed areas caused by pests, disease, or water issues glow red, enabling early issue detection. Another technique is the Integrated Pest Management (IPM) Scope, which complements stress detection glasses by offering a closer look at plant health. This USB-enabled digital microscope magnifies symptoms, records data, and allows for easy sharing via email for quick identification and control measures.
"These affordable technologies, though common in developed countries, are increasingly accessible in the Caribbean and can significantly benefit small-scale farmers by preventing yield losses," says a publication by CABI.

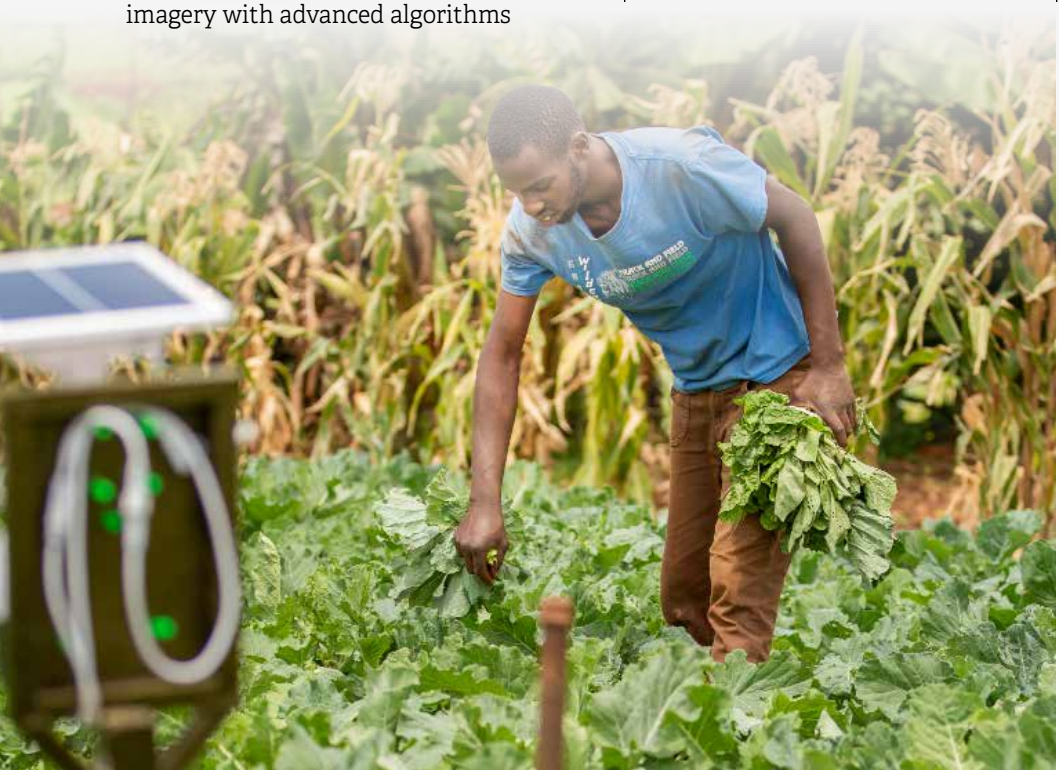
Decision support systems (DSS)

Though varying in their overall function, content, and sophistication, digital DSS are meant to meet user especially smallholders' needs in ways that transcend the capabilities of traditional extension systems and advisory services.

They are not exclusively Internet dependent and often built with the intent of democratising information access across age, education, gender, and socioeconomic classes.

They include the short messaging service (SMS) adapted for rapid delivery of agricultural advisory services, including specific recommendations on best practices to tackle biotic threats on farm, information on specific precautions to mitigate incidence, or timely alerts for risks of pest outbreaks or disease infection and spread.
In coastal Tanzania, for instance, CABI and partners have facilitated SMS messaging among farmers to enable them share information about cassava whiteflies (Bemisia spp.), a major pest in the region, and how to identify and remove infected cassava plants.

Other forms of DSS are Smart Applications (Smart Apps) and Interactive Voice Response (IVR) Advisory.



A vegetable farmer. Photo Credit: Zablon Oyugi