The Global Plant Health Centre: Building a Surveillance and Knowledge System

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Abstract

Millions of dollars are lost each year to the impact of plant pests and diseases. Plant pest and disease distributions are changing rapidly due to climate change and trade flows. Whether it's a farmer seeking treatment advice, regulatory personnel tracking pest incidence, agricultural suppliers developing pesticide solutions, or government ministries setting policy, all are faced with pest data that tends to be widely dispersed, non-specific in nature, of variable quality, and with only general in-country locations provided. Data from multiple owners urgently needs to be overhauled, integrated and made more geographically specific to meet users' needs and contribute to improved food security. CABI is developing a global early warning plant health surveillance system, which will take geo-specific observations on all major grown food and commodity crops from hundreds of clinics operated by trained plant doctors. These localised data will provide pinpoint-mapped information on new and migrating diseases in a new plant health database, merged with information on their status, detailed description (reported, verified, endemic) and management, together with available risk assessments of future likely threat, epidemiological studies, yield loss statistics, relevant regulatory information and, in time, with weather data to facilitate pest modeling studies.

Introduction: a perfect storm?

Estimates vary about the proportion of food and commodity crops we grow that are lost to plant pests and diseases each year, though most calculations range from 35-40%. What is not disputed is the impact: every day, approximately one billion people go hungry with half of these being smallholder farmers. Today, and every day, according to UNICEF, 26,000 children[1] under five years of age will die, with around half directly as a result of malnutrition. The world, meanwhile, begins to face the challenge of how to feed nine billion people by 2050. More starkly, one child dies every six seconds[2] from a treatable disease resulting from malnutrition – the time it has taken you to read this sentence. This is all against a background of increased demand on water, competition for land, the shifting distribution and range of existing plant diseases because of increased trade and shifting climate patterns, and the constant emergence of new plant health problems. Professor John Beddington, the UK Government Chief Scientist, described the position thus: "There is an intrinsic link between the challenge we face to ensure food security through the 21st century and other global issues, most notably climate change, population growth and the need to sustainably manage the world's rapidly growing demand for energy and water. It is predicted that by 2030 the world will need to produce 50 per cent more food and energy, together with 30 per cent more available fresh water, whilst mitigating and adapting to climate change. This threatens to create a 'perfect storm' of global events." Wasted crops result in wasted lives, wasted resources and lost opportunities. Meanwhile, millions of dollars are being lost each year to plant pests; more is wasted on inappropriate treatment regimes, in part due to a lack of knowledge at the farmer level of correct plant health management strategies. The farmer, although the one directly most affected by this potential storm, is not alone in trying to cope against a background of uncertain knowledge. Everyone, from policy makers to regulatory officers to researchers, and governments to insurers to agrichemical manufacturers, is faced with a plethora of unreliable data. Millions of dollars are also being lost seeking and relying on poor, uncoordinated and widely dispersed information. In the broad and increasingly urgent struggle to improve food security, there is uncertainty over what is known about what is happening on the ground. For instance, in evidence quoted within an All Party Parliamentary Group (APPG) on Agriculture and Food Production report[3], Janice Jiggins of Wageningen University states

"The insect vectors, pests and diseases are moving extremely fast and we have frankly no grip whatsoever over what they might do in the next 20/30 years."

It is clear, though, what these pests and diseases are doing now:

For rice, the staple diet of more than half the world's population and second only to maize in global food production, there are more than 700 known plant viruses, many cause devastating diseases and with wide host ranges. Barley yellow dwarf viruses (BYDV) infects most of the staple cereals—wheat, barley, oats, rye, rice, and maize. Harvests are reduced between 15%-38%. Rice is attacked by fungus causing rice blast, resulting in losses of 10%-30% of the crop every year[4].

For wheat, the International Maize and Wheat Improvement Centre in Mexico estimates that 19% of the world's wheat, which provides food for 1 billion people in Asia and Africa, is in imminent danger from Ug99 (wheat rust)[5]. It is predicted that

- $10 billion (€7.3 billion) worth of wheat would be destroyed if the Ug99 suddenly made its way to US fields[6]
- in the absence of effective adaptation, India would lose 3.9 million tonnes of wheat yield due to climate change by 2020[7]

For banana, the Food and Agriculture Organization (FAO) says that banana bunchy top disease and banana bacterial wilt threaten the food security of 70 million people in Sub-Saharan African, and has called for a global map of banana and plantain diseases to stem damage to the crops that could reach US$4 billion by 2011[8].

It is CABI's belief that food security issues can be addressed, at least in part, through the provision of a global plant healthcare network which both disseminates practical advice to farmers whilst simultaneously capturing and contributing local observations into a coordinated information management system. We have commenced discussions with prospective donors, content partners and prospective customers, to build and deliver such a system. This paper outlines the underpinning market investigations held by CABI in 2009 and the intentions to develop, with partners, a plant health initiative comprising a global network of support services for farmers with a comprehensive new real-time knowledge resource relevant to a majority of disparate users involved in agricultural research, services, monitoring and supply.

What users want: the challenge of information access and maintenance

We held interviews with a range of information users across all geographic regions in government, consultancy, industry and academic research, including librarians, each lasting approximately 90 minutes, which focused on understanding the typical work behaviour of each user group. It was important to gain insight into the respective strengths and weaknesses of existing resources and the challenges faced by professionals in locating and accessing relevant content. We were looking for any evident gaps in information provision, and how, once found, any gathered intelligence fed into users' typical workflows and thus into day to day and longer term decision making processes. Although the needs of each audience were subtly different, it was evident early on that their requirements often overlapped and that users faced common frustrations. Namely, some of these were:

- Country specific data, whilst users often wanted a regional or global perspective
- Crop specific data, whilst users wanted to minimise the number of sites to monitor
- Potentially aged data, with no indication how relevant the information remained
- Potentially unreliable data, with uncertainty over data quality assurance
- Widely dispersed data, with users having to spend significant time tracking down relevant information of uncertain veracity before undertaking any analytical work

Information consumers urgently sought a timely and comprehensive information centre with interrogative data and access to bespoke plant science expertise. No single organisation currently holds such a remit but several, including CABI, have datasets which could contribute to a solution. Furthermore we argue that CABI, with the global remit and support from its 46 member countries and expertise across a broad range of plants, pests and diseases, could provide the foundation for a collaborative plant health initiative that deals with the challenges outlined above.

Origins of the system

Drawing together what exists and adding what does not

CABI has a vast repository of agricultural science intelligence published across multiple platforms, together with outputs from development aid projects undertaken in recent years, not widely disseminated but containing some complementary results and analysis. In many cases, CABI products are recognised as the largest data resource of their kind. *CAB Abstracts* contains 6 million records, including 72,000 full text documents, from over 7000 academic journals and 3500 other document types such as reports and proceedings indexed annually; over 75% of the full text content is not available electronically anywhere else. The *Crop Protection Compendium* stores the largest collection of plant pest and disease datasheets in the world with 2,800 detailed information listings and over 27,000 partial briefings, together with 6,000 images. CABI also has a significant collection of other images, digitised books, and a comprehensive set of over 1,500 plant pest and disease distribution maps.

To deliver a more effective healthcare resource we need to update and integrate this data into a database that can be mined for information correlations, providing detail where this is currently absent. What has also been missing is the ability to cross search against relevant plant and weather data from other providers, and the absence of consistent geo-specific coordinates for plant pest presence, affected by and inextricably linked to climate changes, that would give consumers a true impression of what is occurring on the ground. So whilst we have a large bank of trusted data, this could be strengthened through improved internal and external integration and, critically, through the addition of reliable, localised plant health surveillance reports. These can readily be generated.

For over 10 years, CABI has managed an initiative known as the Global Plant Clinic (GPC). There are now nine self-sustaining country schemes (for example, in Bolivia, Sierra Leone, Nicaragua and Bangladesh). CABI provides training and support to a group of national plant doctors affiliated with established in-country organisations, with advice on recognising plant symptoms and the effective operation of rural clinics. Typically the GPC staff will work with government agriculture departments to establish these regular health clinics within the context of a national plant health system, whilst also leveraging the support of diagnostic laboratories and input suppliers. Samples which cannot be identified locally are diagnosed in GPC laboratories in the UK. The system is simple yet effective, and has resulted in 44 new disease records being identified in the past three years.

Farmers have benefited demonstrably from the advice gained through plant clinics. Table 1 shows one of the findings of a recent internal, unpublished, impact study undertaken in Bolivia, where the average income gain was $1400 (€1020).

Table 1. Average benefits by adoption of the clinic recommendation

	Benefit in Bolivianos	**Benefit in US$**	**Benefit in €**
Clinic users that did not adopt clinic recommendation	170	24	17
Did adopt	10,023	1,431	1,043

There are currently a total of 80 regularly run clinics per year; internal studies suggest that clinics reach 1000-2000 people, though more investigation is required.

Although systematic approaches to data collection in human and animal health have become well-established, no such scheme is in place for plant pests and diseases, yet with the impact of trade patterns and climate the need is evident and immediate. Once again, from the APPG report *Why no Thought for Food?* "The increasingly rapid movement of both plant and animal diseases is also linked to climate change. Examples include: viruses such as foot and mouth, bluetongue, avian influenza; plant diseases such as those spread by whiteflies; and pests such as diamond back moth. These were, until recently, largely unknown in countries like the UK but they are spreading faster than previously anticipated, and are threatening livelihoods and economies in both the developing and developed world regardless of country borders." Plant doctors attending clinics are in the best position to provide first reports on new diseases, and have the means to capture and track migrating plant health problems. Simple geo-positioning technology on a mobile phone is allowing CABI the means to input geo-specific reports of disease reports, so that a disease map that previously, typically, carried a pin in the middle of a country's digital map, can now be more specific. By increasing the number of data collection points CABI believes we can rapidly develop an international surveillance system capable of monitoring pests and diseases, and predicting their impact on neighbouring territories. Indeed, subject to secured funding, our intention is to increase the number of plant healthcare schemes to 40 countries by 2015, each with 10 or more regularly run clinics operating across each country. With 400 data collection points inputting plant observations to a database, the peer-reviewed content from CAB Abstracts, compendia, and disease information sheets will for the first time be merged with real-time reports of conditions on the ground.

Partnerships

Information management: how it fits together

With more trained doctors, CABI will reach more farmers with locally relevant best practice advice on how to improve crop yields and thus personal livelihoods. However it is no longer a question of plant doctors or extension workers being just the end-point of filtered down plant science expertise: they become a unique source of vigilance – local expertise influencing global knowledge so that other user groups may also benefit from a consolidated information collection. Those groups include

- Regulatory staff, including quarantine officers, monitoring current pest status information and accurate certification
- Pesticide manufacturers seeking reliable predictive forecasting to assess product development risks, and to determine the associated return on investment
- Government policy makers and analysts needing comprehensive evidence-based pest risk assessments which consider the threat of pathogens, and the adaptation and mitigation strategies that need to be enacted on the ground today, either to protect rural livelihoods or the macro-economic contribution of key cash crops.

An indicative list of overall user needs is shown in Table 2:

Table 2: User groups' reported information needs

Required feature	**Government & NPPO, incl. quarantine officers; import/export**	**Commercial (Chemical companies; food & food processing industries)**	**Risk managers; brokers; crop insurers**	**Farmers/Small holders/plant doctors**	**Academic researchers & teachers**
Pest distribution data (real-time)	X	X	X	?	X
GIS/geographic granularity	X	X	?		X
Verification: level of incidence	X	X	X		X
Verification: ageing of data	X	X	?		X
Risk assessment: % impact on crop yield from pest	X	X		X	?
Risk assessment: $/macro-economic impact	X	X	X		
SPS legislation (local, regional, with trading partners)	X	X (permissible pesticides by country)		X (permissible pesticides)	
Datasets – historic/predictive		X	X		
Pest risk analysis – mid- to long-term (3-10 yr) forecasting	X	X	X		X
Pest risk analysis – short term (1-2 yr) forecasting	?	X		X	
Best practice crop storage & distribution	X			X	
Pesticide take-up & residues data (localised information)		X (linked to SPS requirements)		? (Basic information)	
Treatment sheets – best practice (chemical/biological)	X			X (viable and permissible)	
Predictive forecasts	X	X (one-off versus recurrent threats)	X		
Pest Alerts & Surveillance gathering system	X	X	X	X	
Pest alert interpretations	X	X	X		
Modeling (incl. variability factors)	X	X	X		?

Weather data	X (regional) (linked to disease forecasts)	X (regional)	X (regional)	X (local)	?
Pest descriptions & images	X	X		X	X

What will be delivered and when

CABI is developing a prototype through 2010 to provide prospective donors, content partners and customers a proof of concept model to encourage their participation in the development of functionality, initially using at its core current CABI content (e.g. from the *Crop Protection Compendium*). Discussions are underway with content partners to incorporate complementary datasets into a mash-up suitable for textual and numerical mining, with a user panel being appointed to provide independent editorial and technical guidance to ensure the development is a true partnership that reflects the current and predicted needs of users. The prototype will focus initially on building detailed information on a limited number of crops, developed into a plotted set of data based on the dimensions of crop disease and time before the release of a commercial product in late 2011.

The planned outputs of the database will enable governments and companies to assess the rate and pace of migration of plant pests and diseases: better forecasting will help in mitigation and adaptation, or confirm the demand for new pesticides. By overlaying pest distribution maps with weather models or even digital soil maps, it should be possible for expert modeling and analysis of the many variables that impact the accuracy of disease predictions and pest risk assessments. The accumulation of such granular information over five to ten year timeframes has the capacity to provide insurers with reliable and quantifiable measures upon which they can determine risk, and offer to those farmers who can afford it insurance against pest outbreaks in the same way that farmers currently can insure for weather impact. Meanwhile, those tasked with monitoring food security and safety, from quarantine officers to seed importers and food suppliers, would have at their disposal a current pest problem reporting system linked into existing pest reporting mechanisms such as the IPPC. Pest monitoring and biosecurity subsequently could benefit from being an offshore rather than in-border control.

Much is planned and much remains to be done in determining further the needs of customers, the preferred business model, and the securing of additional donor funding over and above CABI's own investment. The will is there, however, and the need is now – back to Janice Jiggins: "The time period in which to act and start speaking on this is extremely short because these things are already happening and they are increasing."

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