



Compilation of PlantwisePlus output-level reports

2022

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List of acronyms

BARI	Bangladesh Agricultural Research Institute
CBSD	Cassava brown streak disease
EPPO	European Plant Protection Organization
FAFS	Farmer Agribusiness Facilitation Service
FAO	Food and Agriculture Organization
FAQ	Frequently asked questions
FPOCK	Fresh Produce Consortium Kenya
FtMA	Farm to Market Alliance
IAS	Invasive apple snail
IPM	Integrated pest management
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plant Health Inspectorate Service
KII	Key informant interviews
LTEM	Learning Transfer Evaluation Model
MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
MoU	Memorandum of understanding
MRL	Maximum residue limit
NPPO	National plant protection organizations
POMS	Plantwise Online Management System
PP&FSD	Plant Protection & Food Safety Directorate
PPP	Plant protection products
PPRSD	Plant Protection and Regulation Services Directorate
PRA	Pest risk analysis
SEO	Search engine optimization
TRF	Trichogramma Rearing Facility

PlantwisePlus Specific Objective 1: To enhance knowledge and uptake of climate-smart plant health practices through responsive digital advisory tools

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Output 1.1: Digitally supported “PlantwisePlus Toolkit” developed to facilitate implementation of sustainable and safer agricultural practices

Executive summary

The flagstone accomplishment in 2022 was the development and launch of the PlantwisePlus Toolkit. The toolkit serves as a one-stop shop, allowing users to find and access vital decision support tools easily. The toolkit brings together the following:

- an upgraded PlantwisePlus Knowledge Bank, which offers open access plant health diagnostic and management information
- the Plantwise Factsheet Library, which is full of practical information and actionable advice developed under PlantwisePlus and Plantwise
- the Crop Sprayer dosage calculator app, which supports rational pesticide use
- the Crop App Index, which provides a guide to a wide range of agricultural apps and tools

The development of the toolkit and upgrades to existing tools drew heavily on lessons learned from previous digital projects. Core principles and practices included:

- the use of user-centred design to involve users throughout the development process, ensuring that tools are valuable to users and are integrated into their workflows
- a focus on accessibility and a seamless user journey
- lightweight page design to minimize bandwidth and data requirements for users
- responsive design, with specific considerations for users on mobile, small tablets, medium tablets and desktop
- full compliance with Google Play and App Store requirements, including data safety considerations

The PlantwisePlus Toolkit aimed to include third-party apps which are easy to use, offer safe and effective information applicable across a range of crops and countries, and are free for the user to use without promoting particular brands of products. However, these criteria were too narrow and excluded the decision support tools identified and short-listed by a CABI review of agricultural apps, so these criteria will be revised.

CABI is committed to the sustainability of digital tools and recognizes that this is an area where digital interventions commonly struggle. As part of designing a sustainability model for the PlantwisePlus Toolkit, sustainability lessons from other digital interventions have been collated. In 2022, a series of key informant interviews (KIIs) were conducted with CABI staff and select partners to identify the barriers and enablers that should be considered when developing sustainable digital tools. Several themes came out during the KIIs, and these were gathered together into a report, which will be used to inform the development of future sustainability models for the programme.

Some tools, such as the PlantwisePlus Knowledge Bank, have seen significant upgrades this year, while others, such as the Plantwise Factsheet Library, have had small but significant adjustments. Each mobile tool has had updates to align with the latest Google Play Store and App Store demands, including data safety requirements.

The Crop Sprayer dosage calculator app has been developed, and key users have provided input throughout the development as part of a user-centred approach. This will be key in ensuring this tool is valuable to its users and integrated into their workflows.

The Crop App Index was launched in early 2022. It has already proven popular with users seeking to find a digital tool that can meet their needs, either through enquiries to CABI or independently.

Progress and lessons learned

The development of the PlantwisePlus Toolkit platform was completed in 2022. The toolkit serves as a one-stop shop, allowing users to find and access vital decision support tools easily. The toolkit brings together the following:

- an upgraded **PlantwisePlus Knowledge Bank**, which offers open access plant health diagnostic and management information
- the **Plantwise Factsheet Library**, which is full of practical information and actionable advice developed under PlantwisePlus and Plantwise
- the Crop Sprayer dosage calculator app, which supports rational pesticide use
- the Fertilizer Optimizer Tool, which helps users to make efficient use of fertilizers to optimize their budget
- the CABI BioProtection Portal
- links to digital learning courses on CABI Academy and digital learning simulator games

The PlantwisePlus Toolkit links to key decision support tools aimed at supporting agricultural service providers in their work. These tools are applicable across PlantwisePlus countries and focus on subjects including diagnostic support and plant protection information.

After user research in 2021 and 2022, a considered design for the PlantwisePlus Toolkit was developed. This focused on keeping the pages light so they would load quickly for those with low bandwidth and would not use up users' data allowances unnecessarily.

The PlantwisePlus Toolkit was developed on a third-party platform, which is efficient in terms of development time and ongoing costs, and will contribute to its sustainability.

Lessons learned from previous and ongoing development projects were applied to the approach for the Toolkit site, including the method for providing translations, optimizing the search engine optimization (SEO), and the balance between the use of existing plugins and the weight this adds to the page.

Third-party tools identified through the Crop App Index were reviewed on certain criteria, including their usability, global application, application across a range of crops and pests, quality of information, and business model. The PlantwisePlus Toolkit aims to include third-party apps that are easy to use, offer safe and effective information applicable across a range of crops and countries, and are free for the user to use without promoting particular brands of products. A review of many decision support tools identified the fact that it is difficult to find tools that fit all of these criteria. The very best tools often cost money or include adverts or links to particular products for purchase, or are very specific to one crop or one pest, allowing them to specialize in that area. It is clear that if third-party tools are to be included in the Toolkit, the criteria will need to be relaxed in certain areas: for example, geographic application.

The PlantwisePlus Knowledge Bank is a core component of the PlantwisePlus Toolkit. It was developed under the Plantwise programme between 2012 and 2021 and has been significantly upgraded and expanded under PlantwisePlus. In 2022, the site moved to a new platform with an improved look and enhanced search functionality. These were two of the key areas identified for improvement by users during user research in 2021.

On its new platform, the PlantwisePlus Knowledge Bank will benefit from improvements made to other CABI Publishing products, which is an exciting step for this product. While the PlantwisePlus Knowledge Bank has now joined other CABI products on this new platform, it remains an independent product, and so there is also the flexibility to customize the product for target users of the programme, such as agricultural service providers. This includes the unique diagnostic tool, which takes advantage of the wealth of CABI data on pest distribution, pest-host information, and other key data. The migration to the new platform was thoroughly tested internally and with users once ready. Some further future developments have been identified which will further enhance the user experience, particularly with regard to the Knowledge Bank's diagnostic tool.

Another area identified by users for improvement this year was the need to review the materials contained in the PlantwisePlus Knowledge Bank, many of which were written in the early stages of the Plantwise programme. Several countries reviewed Pest Management Decision Guides and Factsheets for Farmers this year, including Rwanda (41), Kenya (103), Uganda (8), Nicaragua (5), India (7) and Pakistan (105). The reviews paid particular attention to the chemical control options, ensuring that the listed chemicals were registered for use and effective against the pest.

Work has also started on developing a list of highly hazardous pesticides, which will include pesticides containing active ingredients that do not meet the criteria for featuring on the Plantwise Red List but which should be highlighted in materials as requiring additional precautions to be taken during application.

There are over 7,000 external links in the Knowledge Bank, and changes to external websites often require updates to these links. Previously, this required the Knowledge Bank team to identify and fix these manually. To monitor these links and improve the efficiency with which they are fixed, a new automated checking system was set up, and 1,200 links were updated in 2022 to ensure users can still access actionable plant health information. New external content was also added in 2022, with a particular focus on materials related to climate-smart agriculture.

Updates to the Plantwise materials were also uploaded to the Plantwise Factsheet Library app, both Android and iOS versions. A full user experience (UX) review of the app was conducted, which showed areas that needed improvement: for example, some of the colours and button sizes could be adjusted to improve the app's accessibility. These updates, although small, can have a significant impact on user experience. The app enables offline functionality by downloading the Plantwise factsheet content onto the user's device so it is still accessible without an internet connection. However, users with mobile devices with limited storage space may be unable to access the information since they cannot download the country pack. After discussion with affected users, an alternative option has been designed so that users can opt to download the content without images if their pack fails to download. Improved information on the size of the country packs will also be provided to give users visibility of the requirements for downloading.

The Crop Sprayer app was designed with input from agricultural service providers in two regions to support their role of giving farmers information about buying, mixing and applying the correct amounts of crop protection products. After gathering feedback on an early prototype of the app at the end of 2021, the first version of the full app was developed in 2022 and was tested with user groups in 2022. Feedback was extremely positive, particularly from agro-dealers, who said farmers frequently ask them to perform these calculations and that the Crop Sprayer will help them to provide quick and accurate information to the farmers. Feedback from these groups also shows that farmers often have more confidence and trust in advisors that use digital tools, and it is hoped that this will increase the farmers' trust in the dosage given to them, which will prevent them from overusing chemicals. The app has been released to the Google Play Store and is currently available in English, Bengali, French and Spanish.

By the end of 2022, the CABI BioProtection Portal had welcomed 1,037,091 visitors since its launch in February 2020. Five new countries were made available on the site in 2022 – Australia, Costa Rica, Ivory Coast, Sri Lanka and Nepal – bringing the total number of countries to 32. Data for three new countries (USA, Indonesia and Malaysia) have been prepared and are now awaiting translation and/or testing before being loaded onto the Portal. Permission to show registered biopesticide and biocontrol data has been received from eight countries – Denmark, Czech Republic, Austria, Sri Lanka, Indonesia, Vietnam, USA and New Zealand – so these countries will be added to the Portal in 2023.

At the end of 2022, there were a total of 3,937 products available on the CABI BioProtection Portal, providing growers with solutions against 927 pests. An offline version of the Portal was launched in 2022, so users can now use the tool where internet connectivity is poor or unavailable.

Two new sponsors have signed a three-year agreement in support of the Portal, meaning it now has 14 partners, six sponsors and five donors. This private sector income is crucial for the future sustainability of the Portal. The three partners who were the first to sign an agreement in 2019 have renewed their partnership for another three years. Extensive analysis of potential sponsors in the coffee and cocoa industries has been conducted, and a sales pitch (in the form of a PowerPoint presentation) has been developed to seek new sponsorships in 2023.

All partners have been given access to user analytics dashboards and training on how to use them. Collaborative work was conducted with Rainforest Alliance, a sponsor of the Portal, with the result that their logo is now displayed against products on the Portal that are compatible with the Rainforest Alliance certification standards. This gives growers working under the scheme more guidance on product selection.

Finally, a review was undertaken to investigate user experiences with the Portal. Subsequent work has commenced to improve the site in light of the findings, with specific priorities to increase the site speed and reduce the number of clicks required to perform a product search.

Feedback on the two simulator apps developed by CABI, the Pest Diagnostic Simulator and the Crop Management Simulator, continues to be positive. However, one of the points raised by users of the Pest Diagnostic Simulator is that it would better support learning if there were some additional help text at the end of each level that would offer help if a maximum score was not achieved. New educational text about the pests portrayed in the Pest Diagnostic Simulator were developed using CABI's plant health expertise, and designs were created to enable this to be best communicated to users of the app. Both the Pest Diagnostic Simulator and Crop Management Simulator have had the regular updates required to remain in line with Google Play Store requirements, including in regard to data safety information. This highlights that even when apps are not being actively developed, they still require maintenance to keep them in line with the evolution of data protection requirements, as well as the technology itself.

The PlantwisePlus Toolkit focuses on the tools that support decision-making by agricultural service providers across PlantwisePlus countries. Several other digital tools are maintained under the Plantwise programme but still need to be integrated into the Toolkit as they have a different purpose or are aimed at different stakeholders within the plant health system. These include:

- the Crop App Index
- the Plantwise Online Management System (POMS)
- the Data Collection App and Desktop Data Collection App
- the Invasive Species Compendium

The Crop App Index is a directory of agricultural apps and decision support tools. It launched in February 2022, covering 350 tools, and by October 2022 covered over 500 tools, with more being added regularly. The Crop App Index began its development in 2021 with the aim of supporting ongoing inventorying of crop-related apps. This landscaping activity started manually, but as new apps and tools are developed regularly, maintaining a manual process would have required significant staff time. The Crop App Index enables new apps to be highlighted to CABI shortly after publication, as they are picked up automatically.

The Crop App Index also serves as a way to more easily discover the digital tools that are available to support decision-making in crop production and plant health due to the additional metadata tags added by CABI. The digital tools pulled in for consideration are picked up using a set of keywords. These keywords have been refined throughout 2022 to ensure all relevant tools are identified and can be processed for inclusion in the Crop App Index while minimizing the tools that are not relevant and need to be rejected.

As the digital development work under PlantwisePlus becomes increasingly well-known, users are contacting CABI to enquire about tools for particular needs, including specific crop and country combinations. The Crop App Index allows us to find the answers quickly and point users in the direction of the Crop App Index so they can go straight to the site for any future needs. The Crop App Index has been promoted in target countries and has seen over 15,000 users since its launch.

POMS continues to be used by partners to access vital clinic data. Support is provided by the PlantwisePlus Knowledge Bank and regional CABI staff to programme partners on the plant clinic data management processes, including harmonization, data analysis and reporting. An API was developed to allow countries to opt to continue to submit data to POMS and display select analyses on their own platforms. This improves the use – and therefore the benefits – of the data, which contributes to the sustainability of Plantwise clinic activities. The API, and POMS as a whole, were thoroughly tested to ensure that the robust security of POMS, which partners trust, is maintained.

The amount of data in POMS is increasing, particularly for countries like Pakistan, which already have huge amounts of data. To address potential problems with handling and analysing large datasets, an investigation into the analysis tools was made, with the aim of future-proofing the system for further increases in clinic data. These modifications will be implemented next year, with the added benefit that the analyses will load faster on weaker connections.

The Data Collection App remains the primary method of submitting data to POMS. A system for identifying bugs in the app without a user needing to report them to CABI was implemented, providing a much better understanding of what is happening when the app is not behaving as a user would expect. CABI's dedicated mobile developer monitors the analytics data collected through this tool to resolve any issues quickly. Users have requested a way to share the data before it goes into POMS: for example, to print it out for farmers if resources allow. This has been investigated, and a solution is being lined up for development.

In addition to these digital tools, the Invasive Species channel in the CABI Compendium (formerly the Invasive Species Compendium) was also supported by PlantwisePlus in 2022. The funding was in line with the agreed-upon decreasing scale of support, as alternative funding sources are secured. In 2022, with PlantwisePlus funds, 38 datasheets have been either written or have undergone major revision and have been published in the open access channel, including datasheets on invasive nematodes such as *Meloidogyne artiellia* and weeds such as *Acacia polyacantha*. Through three other projects, funded by the United States Department of Agriculture (USDA), a further 157 datasheets have either been written or have undergone major revision, have been published, or are in the publishing pipeline for 2022.

As well as the writing and revision of datasheets, the CABI Compendium's plant pest distribution data, which is also used in the PlantwisePlus Knowledge Bank, have been updated through four quarterly uploads of new distribution records, 2,987 in total, which were text-mined from the world's scientific literature in a process carried out alongside the abstracting and indexing workflow for the CABI Abstracts bibliographic database. Similarly, four uploads in 2022 of new host records for pest species covered in the Invasive Species channel and PlantwisePlus Knowledge Bank were discovered and aggregated in a related process. This has resulted in an increase of 2,830 pest-host relationship records. In addition to these quarterly updates, in a process that is carried out annually, the latest data (67,578 records) from the European Plant Protection Organization (EPPO) Global Database was uploaded to enhance and update the pest distribution data.

CABI is committed to the sustainability of these digital tools and recognizes that this is an area where digital interventions commonly struggle. As part of efforts to design a sustainability model for the PlantwisePlus Toolkit, sustainability lessons from other digital interventions were gathered through a series of KIs with CABI staff and select partners to identify the barriers and enablers that should be considered when developing sustainable digital tools. A number of themes came out during the KIs, and these were gathered together in a report, which will be used to inform the development of future sustainability models for the programme. The themes identified include considerations such as the value of data, the flexibility of the tool for adaptation, the trust of users, and some more practical areas, such as setting up maintenance agreements or refining the workflow of newly developed tools as saleable products.

Next steps

During 2023, the PlantwisePlus Toolkit will be refined based on user feedback, including continual efforts to keep pages as lightweight as possible while optimizing the user experience across target PlantwisePlus countries. User feedback will be gathered through 'FullStory' videos and direct user engagement. The Toolkit is currently available in five languages – English, Spanish, French, Bengali and Urdu – with additional languages to be added in 2023.

In 2023, criteria for a third-party tool that PlantwisePlus will partner with will be reviewed so that a tool can be selected and the developing organization approached for inclusion in the Toolkit, either as it is or after some refining or expanding – for example, expanding it to additional crops or countries. The data collected through the Toolkit will also be reviewed to learn more about who is using the PlantwisePlus Toolkit and what they are using it for. This is essential to ensure the site achieves its desired impact.

On its new platform, the PlantwisePlus Knowledge Bank will benefit from the improvements made to other CABI Publishing products. Plans for 2023 include continuous improvement of the search results and search refinement and drawing on insights gained from usage. The PlantwisePlus Knowledge Bank will also benefit from increased usage, as users of different products on this platform will have another way to discover the site. Research gathered from site users highlights that they like images, multimedia and other visual communication, so this will be reviewed regarding the Knowledge Bank. The diagnostic tool, which provides images in its results page, will be one area of focus for this, as the images vary in quality and relevance to agricultural service providers working in the field.

Content in the Knowledge Bank will continue to be updated with input from PlantwisePlus partners, and broken links will be fixed in a timely manner. Additional climate-smart content will be added to the Knowledge Bank, with one particular aim being to include content with actionable information for agricultural service providers, as providers currently often need clarification on this type of advice.

To further support PlantwisePlus's aim to ensure the safe use of agrochemicals, further guidance will be added to Plantwise materials that recommend active ingredients which, while not restricted by international conventions and which thus do not feature on the Red List, are hazardous and so should be applied with extra precautions. The PlantwisePlus Knowledge Bank will be connected to the Pulse system (Output 1.2) in 2023, and there is additional information, such as the user's role, which will be valuable to collect from Knowledge Bank users. This has to be balanced with the value users get from supplying additional information, which requires some investigation.

User feedback on the Crop Sprayer dosage calculator tool will be gathered in early 2023. Based on feedback from users, the current functionalities of the tool will be refined, and additional calculations or functionalities will be added. The workflow for moving between calculations will be reviewed, and additional links will be added to ensure users have relevant information to support the rational use of pesticides. The data collected through the tool will be monitored, and additional opportunities for data collection through this tool will be assessed to generate insights which will feed back into the PlantwisePlus programme.

The CABI BioProtection Portal will see a further 13 countries added in 2023, including Sri Lanka, Vietnam, Indonesia, Mozambique and Tanzania, so it houses a total of 45 countries by year-end. Efforts will also be increased to acquire new partners and sponsors for the Portal. The emphasis will be on targeting new biocontrol manufacturers, foundations and trusts, as well as corporate companies in the food commodity industry.

Improvements to the Portal site, based on the user experience review carried out in 2022 (a new design that is faster and with reduced clicks), will be continued. An SEO review will also be conducted, and recommendations from the review will be included in the site development work to ensure maximum performance on search engines and optimal generation of organic (non-paid) traffic to the site. As a result of this work, a newly designed site is expected to be launched in quarter 2 (Q2) 2023.

Market insight reporting capacity will be improved so that data on Portal user analytics and product availability can be combined to generate unique and insightful reports for partners in the future. Meetings will be held with partners to gauge interest in these reports, and a business strategy for how these can generate income from/benefit the Portal will be developed. In the meantime, 'quarterly usage flyers' will be generated and sent to partners to provide regular updates on the Portal's current usage and interesting market trends. The resources section of the Portal will be further developed to improve

users' awareness and understanding of biocontrol. Further efforts will also be made to identify the most appropriate and effective channels to communicate (through non-paid means) to national public and private sector agriculture advisory services about the Portal to boost the number of engaged site users

After the Pest Diagnostic Simulator app is upgraded and promoted to target users, an assessment will be completed, once users have had the opportunity to complete several levels of the game, to gauge the value they see in the app with the addition of the improved educational information. One of the current limitations of the tools is the lack of translations, and so an investigation will be conducted into adding the ability for users to see the content within the app in their own language.

The Crop App Index will identify decision support tools that could support PlantwisePlus stakeholders in their work. In order to keep the Crop App Index relevant and useful, new digital tools will be added to the Index as they are published.

To ensure POMS is offering partners the most useful analyses, these will be reviewed and improved. The loading speed will also be considered as part of this, especially in countries which have amassed a large dataset. The approach investigated in 2022 will improve this for the users and should increase engagement from partners, who can get frustrated if they are on a weaker connection and actions time out.

With the new automated system for logging issues with the Data Collection App, bugs should be identified and resolved quickly so as not to delay the submission of clinic data. The communication of basic troubleshooting will also be improved to support partners in managing the challenges themselves.

In line with its sustainability plan, support for the Invasive Species Compendium continues at the agreed decreasing rate. Support in 2023 will focus on reviewing datasheets, which is key to the maintenance of the product, as well as regular updates to the pest distribution and host data, which also benefits the PlantwisePlus Knowledge Bank and other potential tools.

A workshop will be conducted in early 2023 to validate the findings of the KIs on different business models that can ensure sustainability. Discussion between the key informants will lead the team towards best practices for developing and assessing business models, and will inform the next steps in assessing possible business models for the PlantwisePlus digital tools.

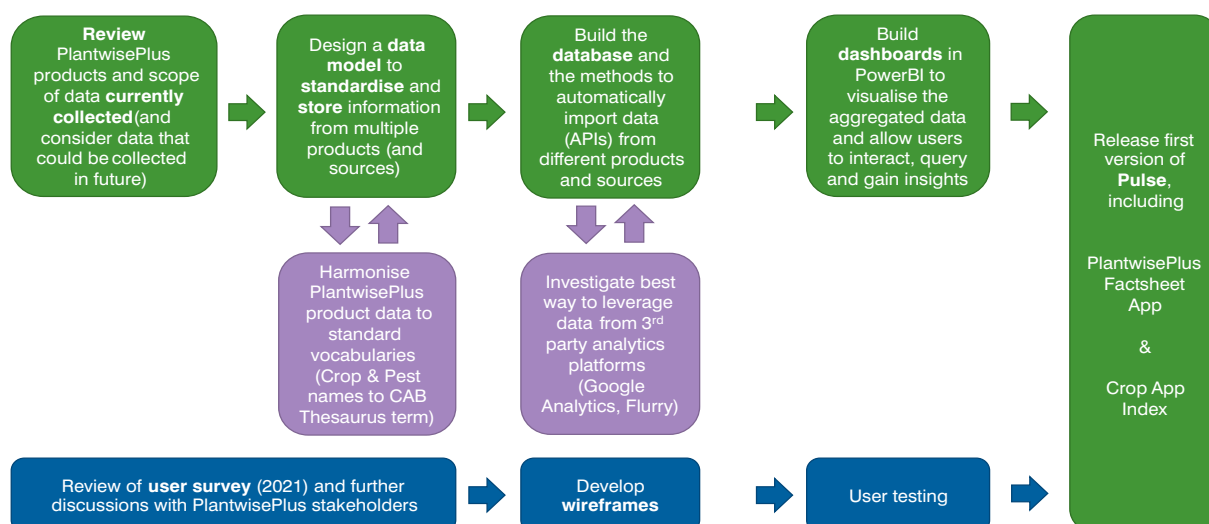
Output 1.2: Effective data collection systems developed and tested for quality assurance and market intelligence through PlantwisePlus Toolkit

Executive summary

A new system, named 'Pulse', has been built to collect, manage and visualize data from PlantwisePlus digital products. Pulse is a new analytics product which will provide insights into the way the PlantwisePlus digital tools are being used, the people using them and the type of information they are consuming.

Throughout 2022, the foundations have been built to manage and store tracking information from the digital tools. Technical investigations have enhanced CABI's understanding of third-party analytics providers and how to optimize PlantwisePlus tools to gather information that will be valuable to the programme. Automated processes will allow this data to be drawn together from different sources, harmonized into standard formats and presented in dashboards which will provide a programme-wide overview of PlantwisePlus tools and users. Product owners and programme leaders will no longer need to visit multiple analytics websites to access different user reports of reach data, or spend time merging disparate information from different sources in order to gain broader insights.

2022 Progress



The first release of Pulse includes incoming data streams from the Crop App Index and the Factsheets Library App, which can be viewed and explored through interactive dashboards.

Progress and lessons learned

Assessment and prioritization of products

An assessment was made of the range of PlantwisePlus products, based on the value of the potential use data that could be gathered and the technical complexity of extracting this information. After consideration, the Crop App Index and Factsheet Library App were selected as the two highest-priority products for inclusion in Pulse for 2022. Information was reviewed from surveys carried out in 2021 as to the important metrics that CABI users wanted to obtain, and additional feedback was collected through stakeholder interviews throughout the year to steer the development of the product.

Building the data model and pipeline

For each product, existing channels of data were identified and assessed. PlantwisePlus products use a range of third-party analytics solutions, depending on the technologies applied when they were created. These include Google Play Store, Google Analytics, Google Firebase and Flurry. Edits have been made to products to standardize the way this information is collected and to ensure that all of the key events and actions that occur during the use of a product are being tracked and recorded. Once stored, this information is either fed directly to CABI databases or to the third-party tools. From there it is transferred at regular intervals via an API in to one CABI database that collates the data. The incoming data is initially stored in its native format. Transformation processes have been designed to convert this data into a standard format and to enrich it with extra metadata. For example, data might be logged that a factsheet with the ID number “20177801116” has been viewed. By joining this information with existing CABI data, information can be added to this event to record that this was a view of content where the problem was “fall armyworm”, the crop was “maize” and the document type was a “Photo sheet”. This transformed and enriched data is transferred to the main Pulse database, built using MS SQL, where it can then be made available through APIs to dashboarding tools.

Interfacing with these third-party tracking tools also brings challenges. One of the major technologies traditionally relied on for tracking online activity, Google Analytics, is about to make major changes. In 2023, Google Analytics version 4 will become the new standard for tracking engagement and traffic on websites and apps. Work under this PlantwisePlus output has included significant investigative work in order to ensure PlantwisePlus products will function with this new technology, whilst also ensuring that the technical solutions built under PlantwisePlus will benefit from the latest updates. With the creation of Pulse, and of the processes for storing this data in CABI databases, there is less reliance on these third-party tools and CABI has greater control over how data is used.

Gathering user data

There are many challenges when it comes to collecting data from users of the digital tools. These range from technical, legal and ethical issues around how data is obtained and used. Laws are evolving around the tracking of behaviour online, and analytics tools change frequently to meet changing regulations. In some territories, laws place a greater onus on users to 'opt in' to tracking, rather than having the option to 'opt out'. This trend, coupled with the move towards employing online security solutions (such as cookie management), may limit the amount of data CABI is able to collect from its tools.

At the current stage of the Pulse project, no data which makes the data subjects (people using PlantwisePlus tools) personally identifiable is included. As the requirements for Pulse change, and if PlantwisePlus wishes to collect personal information in future, more significant data protection implications will need to be addressed. The PlantwisePlus policy on personal data protection should be regularly revisited.

Data harmonization

In order to harmonize data from different products so that it can be compared and analysed, some improvements needed to be made to the data. PlantwisePlus Knowledge Bank extension materials (Factsheets for Farmers and Pest Management Decision Guides) are indexed with key terms using a Factsheet Admin Tool. Over the years, this has been done in a free-text form, employing the local common names used by people in the country to whom the content is relevant, to best serve their needs. This means that many terms that are used are not aligned to a controlled vocabulary. For example, a search in the Factsheet App for pests affecting "eggplant" could not be compared to a factsheet view in the Knowledge Bank where the main crop is "aubergine". Updates to the Factsheet Admin Tool have been made to create new indexing term categories which are aligned to CAB Thesaurus terms, without impacting users' ability to find the content using their local terms. This has improved the harmonization of data and has resulted in cleaner data that can be used for analysis of the content users are viewing across the many products which display PlantwisePlus extension materials. A lesson for the future is that the PlantwisePlus programme must consider interoperability at every stage of product design and development, and must use and support CABI data management and infrastructure tools like the CAB Thesaurus. This will save time and money in the long run when attempting to reuse information in new products or connect data from different products to gain insights.

Initial products

The first products to appear in Pulse are the Crop App Index and the Factsheets Library App. The Crop App Index is a new website which helps users discover the digital tools that are available to support decision-making in crop production and plant health. Being able to track use of this tool will allow the programme to monitor which types of app are in most demand and by which users. The Factsheet App is a mobile app designed to assist extension workers in providing practical advice for tackling crop problems. By recording information on the use of this tool, Pulse users will be able to see trends in the demand for information on certain crops and pests, and, coupled with user information, can explore this data by country or region.

Analytics dashboards

All the information collected by Pulse from PlantwisePlus tools is visualized in dashboards. These charts, graphs and statistics give an overview of programme-wide trends across three key themes:

1. user insights – information about the people using PlantwisePlus digital products
2. behaviour insights – information on how users are engaging and interacting with PlantwisePlus tools
3. agri insights – information about the content users are consuming (e.g. crop and pest names)

The dashboards have been developed using PowerBI, a popular Microsoft interactive visualization software. This is an effective solution for connecting to different types of data from unrelated sources and displaying dynamic information in a coherent and visually pleasing way, with off-the shelf solutions for building interactive charts and maps. Dashboards built using PowerBI are relatively easy to transfer to and publish on other platforms in the future, depending on business requirements. Pulse dashboards are currently hosted on the CABI Analytics website. This location was selected as it is the existing home for CABI analytics and is an access-controlled site where only CABI staff can access the information.

Next steps

Additional data and products

Following feedback, an assessment will be made on whether enough information is being collected from existing Pulse products. Should Pulse users desire more information, further changes to the digital tools themselves will be considered, to make the data available for Pulse users. This may involve adding more custom elements to the tools to request data directly from users, rather than relying on passive tracking information.

Data from the Crop Sprayer app will be added to Pulse in early 2023. The PlantwisePlus Knowledge Bank and its diagnostic tool will then also be included in the system. An assessment will be made regarding the next tool to be added, based on the value of inclusion. The candidates include the Fertilizer Optimizer Tool, the CABI Bioprotection Portal, CABI Academy and the PlantwisePlus Data Collection App.

It is the intention that third-party digital decision support tools will be included in the PlantwisePlus Toolkit. As part of developing partnerships with those third-party organizations, the sharing of data will also be explored, so that data generated through the use of those tools can also be included in the Pulse system; and some defined insights could be shared with those organizations under a reciprocal agreement.

Data-driven alerting

As data is now flowing into the Pulse system, an alert system based on key data-driven events will be designed and implemented. These alerts could be used to warn when certain events or trends are identified in the incoming data: for example, a particular spike in searches for a pest across the PlantwisePlus tools.

Exploring commercial applications

To understand the commercial value of the data derived from Pulse, and the applications for which it could be used, there needs to be a thorough understanding of the types of data that PlantwisePlus tools have the potential to collect, even if they are not currently collecting this data. This could then be used to generate commercial and non-commercial use cases for the data. A report compiled by PlantwisePlus in 2021 showed the types of personal data and search terms or outcome data which can be collected through the PlantwisePlus tools. However, more analysis needs to be done on the types of subject-based data which could be collected from the tools, and therefore the insights that can be gained through Pulse for PlantwisePlus. Insights into users across the suite of tools and geographies would also provide a better understanding of PlantwisePlus tool users. Once there is a critical mass of data, and once some use cases have been generated, these can be presented to external partners to investigate commercial options. These could fall into one of several categories:

1. selling raw data to external parties
2. analysing and presenting value-added data to external parties to contribute to their insights
3. using data internally to improve business value: for example, feeding data into marketing strategies to increase usage, which in turn generates increased data, potentially making greater insights available to customers externally.

Output 1.3: Training and digital learning products created to support capacity building of agricultural service providers

Executive summary

The CABI Academy has achieved significant growth over the past year, with a four-fold increase in enrolments from target PlantwisePlus countries. The number of visitors and registered users continues to increase steadily. A strong team has been built, incorporating people from across CABI plus a small number of contractors.

The CABI Academy platform has been significantly enhanced to allow it to handle translations and streamline the administration of access. The translation feature will make a big difference to the user base who would prefer to use the learning content in their own language, and it will make it possible to reach many more people with the courses. As the number of courses and users has increased, the resources required to manage a large, complex learning platform and its underlying configuration and code have also increased, so additional resources are being arranged for 2023 to ensure that this is not a bottleneck.

The team have continued to make improvements to the Skills Framework for Agriculture, and have developed a prototype [website](#), which has been used to gather some initial feedback from partners. Two self-guided courses, on Crop Pest Diagnosis and Crop Pest Management, were updated in light of user feedback and a user experience review. Meanwhile, a new self-guided course, 'Introduction to Bioprotection Products' was created with associated CABI certifications. Before launch, feedback was sought from a variety of users, including industry. It is really important that CABI continues to develop and nurture connections with both local contacts on the ground in PlantwisePlus countries, as well as relevant private sector organizations.

Initial planning for activities in 2023 has been conducted and resource gaps have been identified. Recruitment is in progress, and the team will onboard new members and further develop plans to achieve targets in 2023. One key activity will be to redevelop the Skills Framework for Agriculture, so that it includes a consolidated set of skills, and mapping these to training and education opportunities. Additional courses and associated certifications will be developed on topics related to sustainable agriculture: for example, water management. While this content is being developed, iterative improvements to the CABI Academy platform will continue to be made to refine the user experience. The user needs will be at the centre of these activities, and so there will continue to be meaningful engagement with the end-users, to ensure their input is incorporated at each stage of course development.

Progress and lessons learned

Growth

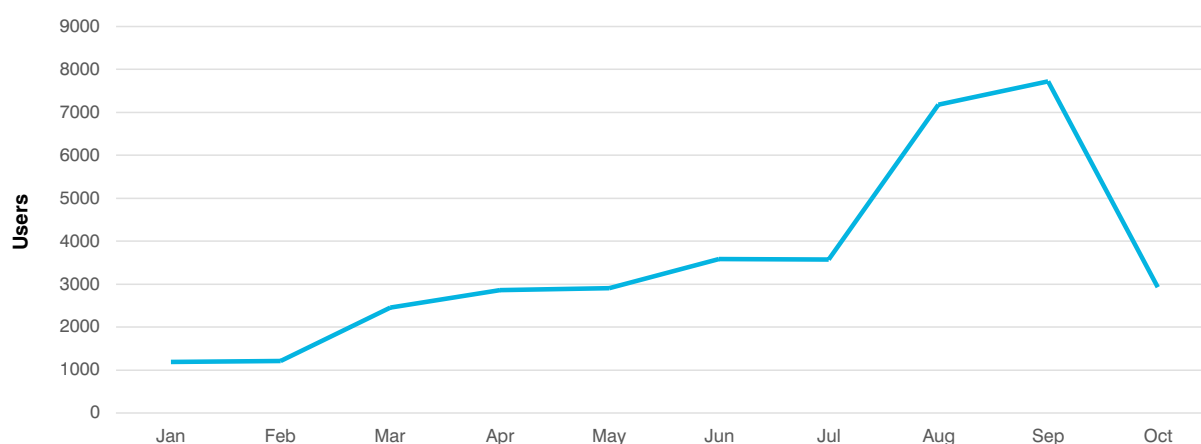


Figure 1: Visitors

Between 1 January 2022 and 2 November 2022, there were over 16,000 unique users of the CABI Academy (Figure 1), with an average (mean) engagement time of over 40 minutes. The peaks in Figure 1 show key points when there was significant marketing activity, including both online and in-person events.

In 2022, there was a four-fold increase in enrolments in the CABI Academy from target PlantwisePlus countries, which for this activity were Bangladesh, Bolivia, Rwanda and Burkina Faso. Where it was possible to measure the sex, there was a male to female ratio of 65% males to 35% females. This appears to be considerably better than the ratio of male to female extension workers in many countries.¹

Skills Framework for Agriculture

The Digital Learning team have worked with CABI colleagues and partners from around the world to develop the first pass of a Skills Framework for Agriculture. This comprises over 200 skills needed for the roles of extension workers and agri-dealers, which are now represented on an alpha (rough prototype) website². The role of the Framework is to provide a common language for skills and competencies across roles in agriculture, starting initially with agricultural service providers. This will allow users to understand and better communicate the skills required for these roles, and will contribute towards building a structured way to assess skills gaps.

Feedback has shown that 200 skills is too many to be useful, and so by the end of 2022 the 200 original skills were consolidated down to 30 skills, each described across up to seven levels. This follows the model of the Skills for the Information Age, an established skills framework for the information technology industry, which provided guidance to CABI on developing the Skills Framework for Agriculture. This has been valuable in ensuring CABI can learn the lessons that other organizations have identified, and ensure efficient development of the Framework.

A Skills Framework Working Group was established to engage and collaborate with external partners on a regular basis. While there have been some extremely engaged partners, attendance at the group sessions has been low. Going forward, it is hoped that the next iteration of the Skills Framework for Agriculture will provide a more tangible product on which future engagement can be based.

New courses and certifications

Two new self-study courses have been designed and are in the later stages of development, with both due to be launched in early 2023. The two courses developed are:

- Introduction to Bioprotection Products
- Reducing Pesticide Risk

Both courses are designed for people who advise smallholder farmers, and have been created with the support of subject matter experts from within and outside CABI. The courses include certification assessments at 'Foundation' and 'Practitioner' levels. Foundation assessments test the learner's ability to **recall** information from the course, and Practitioner assessments test the learner's ability to **apply** information from the course.

The language used has been kept deliberately simple and direct, even using animated videos with no spoken word or text. Early tests have shown that these materials are providing immediate benefit to the target audience, who are able to use them directly with their farmers.

High-quality tutor-led courses leading to three Certificates of Advanced Study in Integrated Crop Management have also been developed. These courses are accredited by the University of Neuchâtel in Switzerland.

The process for developing courses has been refined with each new course and allows the team to work effectively to deliver, in terms of learning design, presentation and editorial standards (see Figure 2). Following an iterative approach, continuous improvements have been made throughout the year

1 Adebayo, O., & Worth, J. (2022). The role of extension workers in agricultural development. In J. Worth (Ed.), *Agricultural extension: A global perspective* (pp. 113-132). Routledge.

2 <https://agriculturekills.org>

using an informal Plan, Do, Study, Act approach³ ('Plan Do Study Act Cycle', n.d.) whereby incremental changes are tested to see if they achieve the planned improvements. For example, the writing process is now led by the learning designer, with input and feedback from the subject matter expert (previously, it had been the other way around). With the new approach, the needs of the learner are the focus, and the activities and content are more streamlined.

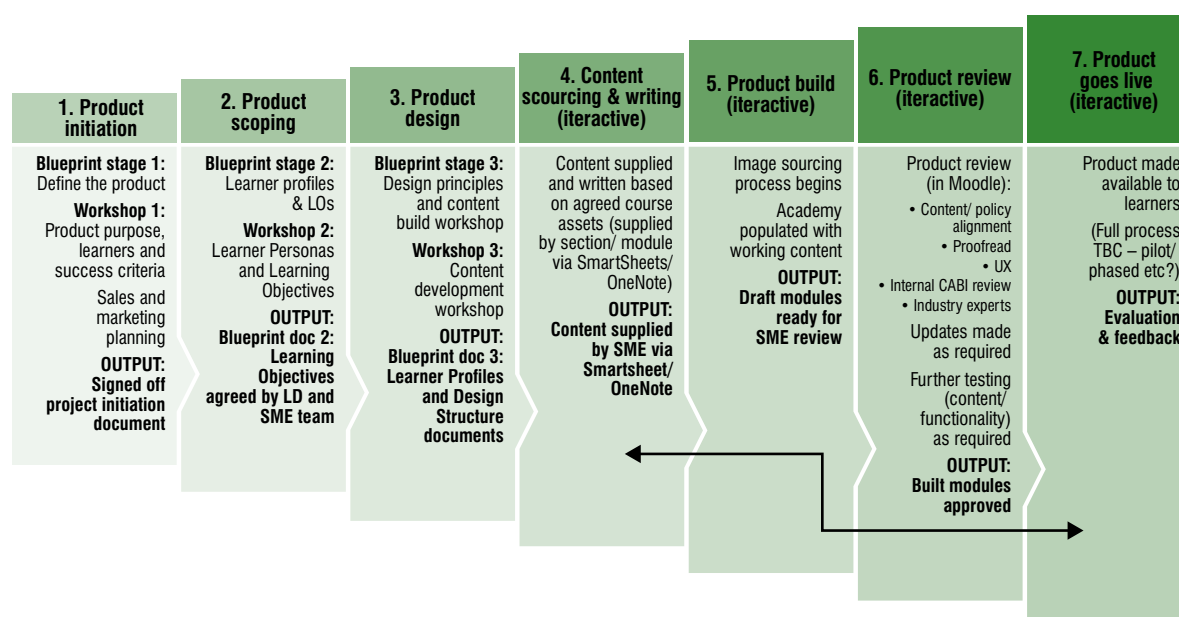


Figure 2: Design process

Legacy course improvements

The results of a UX review led to minor, but important, changes to the navigation of the legacy courses, Crop Pest Diagnosis and Crop Pest Management. Using feedback data and statistical evidence from question banks, significant improvements were made to both the formative⁴ and summative⁵ assessments for these courses. This involved creating new question banks and applying more rigour to the design of the questions. New Practitioner-level certification assessments, designed to assess the learner's ability to apply the knowledge and skills gained in the course, have also been developed for these two courses.

Academy platform

As well as the continuous, minor improvements to the processes, user interface and back-end system, several significant upgrades have also been made to the CABI Academy platform, including the move to an upgraded server to handle the increase in usage. A content translation plugin which allows rapid rollout of content in a new language, via Google Translate, has been added. These translations can then be overridden, if necessary, by nominated people acting as translators. This is already proving worthwhile, with students observed to be using the plugin to support their learning. The plugin allows a new language to be added to the CABI Academy very quickly. However, it has been challenging to implement this with the existing Moodle software, and many adjustments have been made: for example, translations are now cached to avoid high Google Translate fees.

Another addition is an IP-based enrolment plugin that allows rapid access to a whole country via IP address range. Unfortunately, this has highlighted inconsistencies in how some telecom providers allocate IP addresses. For example, some people in Rwanda were appearing to have German IP addresses and, therefore could not enrol automatically in the courses and required additional help to access the courses.

³ Plan Do Study Act Cycle', n.d.

⁴ A formative assessment is designed to give feedback to help improve learning.

⁵ A summative assessment is designed to provide evidence of learning having taken place.

User support

The CABI Academy team had previously piloted the Freshdesk support management system, and since August, this is now in use across CABI. This allows for faster responses to users' questions and issues, management of frequently asked questions (FAQs), escalation of issues, and tracking responses. Currently, most queries are closed within two days of them being raised. Users can access the FAQs and contact the support desk directly from within the CABI Academy platform.

In addition, a short Taster Course was developed and has been made freely available to give people an opportunity to see how the CABI Academy works before undertaking a course for real.

User research

Over the course of the year, interviews have been carried out with users, both to identify the impact of the courses and also to get a better understanding of their needs and their pain points. The results of these interviews have been used to make changes to the CABI Academy platform and to the course materials and assessments. One research exercise fielded a questionnaire to identify the skill areas which the target audience felt were most needed to effectively advise farmers. The questionnaire was completed by 47 participants, mostly from Asia and Africa, with just over 50% from the public sector and about 25% each from the private and not-for-profit sectors. 25% of the respondents were female. Using the results of this exercise, and considering the priorities of PlantwisePlus, an additional five courses and certifications have been identified for delivery during 2023.

Finance and sustainability model

A business model for the CABI Academy that is based on three core components and two types of funding sources is being tested (Table 1). The CABI Executive Management Team is putting together a list of countries where products are provided on an open access basis, and those countries where payment will be required (closed access).

Table 1: Business model for the CABI Academy

Component	Funding sources	
	Global funding agencies	Local funding sources (e.g. country governments, membership organizations, value chain organizations)
Globally applicable courses and certifications	Provide support for initial design and build, and enable open access to lower middle-income countries	Within closed access countries, fund subscription fees giving access to people from those countries
Locally specific courses and certifications	Minimal support expected	Provide support for initial design and build, and ongoing maintenance
Training and education consultancy	Funding for specific projects	Funding for specific projects

Next steps

Skills Framework for Agriculture

In 2023, the Skills Framework Working Group will hold more one-to-one sessions, rather than expecting everyone to join monthly workshops, which will hopefully increase engagement. A new website for displaying the streamlined Skills Framework will be developed, to allow training and education opportunities offered by CABI and its partners to be mapped to individual skills and skill levels.

Product development

The titles of the new courses that will be developed in 2023 are yet to be determined, but these are the subject areas which were requested by users during the user research:

- water management
- soil health
- cropping strategies
- seed and planting materials
- crop nutrition (including bio-fertilizers)

For each of the new products to be developed in 2023, the main user requirements will be well defined up front so that efforts will focus on the needs of the learners from the beginning. In addition, key internal and external stakeholders will be identified at this early stage and involved throughout development, to minimize the risk of last-minute changes. Products will be released as “beta” versions, to make it explicit that they are not yet finished. This will enable the collection of additional feedback before the products go fully “live”.

Platform

The user experience of the platform will continue to be improved, especially in regard to navigation. This will involve making a software upgrade to Moodle 4.x and creating a new CABI-branded theme pack, as well as carefully selecting off-the-shelf plugins and configuration options to help smooth the user journey. Investigations will also be conducted into connecting the platform to the Atypion Connect identity management system. This will enable users to apply their existing identities (including CABI Digital Library, Google, Microsoft etc) without having to create a new one to register with the CABI Academy.

User research

As well as remote interviews, in-person visits will be arranged to enable direct engagement and user feedback, to ensure the best quality feedback. The aim of these visits will be to understand in more detail how people use the courses, to learn more about the pain points they experience, and to see first-hand the context in which the courses are used.

Output 1.4: Agricultural service providers equipped with new digital learning products and decision-making tools

Executive summary

Awareness-raising activities aimed at promoting the PlantwisePlus digital learning products and decision-making tools continued in 2022. Five news articles and 14 blogs were published on the CABI, PlantwisePlus and Invasive blog sites. Flyers for the CABI Academy, PlantwisePlus Knowledge Bank, and PlantwisePlus Toolkit were designed to promote the uptake of the tools. These resources have been translated into Bengali, French, Mandarin and Portuguese, with the CABI Academy flyers also available in Kinyarwanda. Short demonstration videos were produced for the CABI Academy and PlantwisePlus Toolkit to showcase their functionality, with further video design briefs created for the simulator apps, PlantwisePlus Knowledge Bank and Crop App Index. These information resources were made available via a Trello board, as well as through SharePoint.

A new monthly marketing report was created, which provides updates and usage statistics per tool and country. The reports give greater transparency regarding tool usage and provide a place for exchanging information about tool marketing opportunities.

Opportunities to promote the apps through CABI-led activities were taken whenever possible throughout the year: for example, in Bangladesh the digital tools were introduced to more than 6,400 Sub Assistant Agricultural officers as part of a plant doctor training programme.

A Google Analytics dashboard has been created that gives rapid access to the usage figures. In 2022 the PlantwisePlus Knowledge Bank retained its user base, with the number of visits remaining consistent with those seen in 2021, at just over 400,000. Promisingly, there was a 7% increase in organic traffic (via search engines) and an 8.2% increase in new users. The Crop App Index has received 21,940 visits

since its launch in February 2022, with the largest number of users coming from India. Most of this traffic to the Index came from paid ads (87%) with only 10% being returning users. A similar effort to promote the PlantwisePlus Knowledge Bank did not result in a comparable sustained rise in traffic (4% increase). The variation in the effectiveness of ads is assumed to reflect the different audiences for the tools, and their different behaviours. A key lesson is that despite the popularity of Google, paid ads are not sufficient to reach the key user groups of extension workers, agri-input suppliers and farmers. Reaching these groups requires more diverse means, including promotion at face-to-face events and making use of country-based networks, such as social media platforms, SMS, and agricultural-based platforms. CABI's digital learning products and the digital support tools are frequently promoted together, however the development and adoption of training tools on the CABI Academy platform are reported separately.

The outbreak of the Covid-19 pandemic in 2020 resulted in many extension farm visits being discontinued. Governments and other farmer intermediary organizations attempted to bridge this gap by increasing their use of digital tools. A CABI-led study was conducted to investigate the impact of Covid-19 on rural Ghanaian women's digital access to agricultural information (focusing on the use of mobile phones). The study, conducted in the Brong Ahafo region, used a mixed methods approach, including a survey, focus group discussions, and KIs. The data reveals that women's mobile ownership levels have grown since Covid-19, and their use of phones to obtain agricultural information has also changed significantly. The restricted movement necessitated adaptations, such as coordinating market delivery via phone. The new, mobile phone-based ways of doing business have been mostly favourable for women, with reduced costs and time constraints and increased access to timely information. These improvements in utilization are set against a backdrop of gender inequalities in mobile phone ownership and usage. In particular, in the study, more men perceived mobile phones to be a useful tool for accessing agricultural information than did women. Extension services also reported ICT-based adjustments in their work to serve farmers, some of which are expected to continue after Covid under an efficiency/effectiveness agenda.

The findings of the Ghana study will be used to guide how PlantwisePlus approaches the topic of gendered access and use of digital technologies and their relevance for agricultural stakeholders, as well as for national partners.

Progress and lessons learned

Promotional activities to make users aware of the digital learning products and decision-making tools available in the PlantwisePlus programme continued in 2022. Press releases were created for the Crop App Index, PlantwisePlus Toolkit, and CABI Academy launches, and were shared through relevant media outlets. Five news articles and 14 blogs featuring the digital tools were published on the CABI, PlantwisePlus and Invasive blog sites. Flyers to support the promotion of the tools were developed for the CABI Academy, PlantwisePlus Knowledge Bank, PlantwisePlus Toolkit and Crop App Index. Additionally, a PowerPoint presentation providing an overview of each of the tools was produced. These resources have been translated into Bengali, French, Mandarin and Portuguese, with the CABI Academy flyers also available in Kinyarwanda. Short demonstration videos were produced for the CABI Academy and PlantwisePlus Toolkit to showcase their functionality. Further video design briefs were created for the simulator apps, PlantwisePlus Knowledge Bank and Crop App Index. All of these communication resources are available to CABI staff through a [Trello board](#).

A new monthly marketing report structure was developed that provides updates on marketing and in-country activities, as well as providing usage statistics by country. These reports give greater transparency on usage and help to foster an environment that is conducive to sharing information about opportunities for tool promotion. CABI staff based in the Africa, Asia and Latin America offices were contacted to investigate which in-country networks were most suitable for the promotion of digital tools. Opportunities to promote the apps to target audiences were taken whenever possible: for example, in Bangladesh the digital tools were introduced to more than 6,400 Sub Assistant Agricultural officers as part of a plant doctor training programme. Similar opportunities for promoting the tools have been taken in Nepal, China, Ethiopia, Kenya, Bolivia, Peru, Nicaragua and the Caribbean.

Paid marketing activities in 2022 included the use of Google Ads for the Crop App Index and CABI Academy. The CABI Academy pay per click adverts were geo-targeted to PlantwisePlus countries. Keyword research was conducted in order to reach the most relevant users. An SEO audit was also conducted. This provided technical and content recommendations that aim to improve organic traffic to the Crop App Index and PlantwisePlus Toolkit websites. An app store optimization review took place that looked at technical and content improvements for each app within the app store.

In-country activities

During the PlantwisePlus programme so far, it has been found that while for some tools social media promotions are effective, for some it is difficult to engage the targeted stakeholders. For example, in regard to the simulator apps, which require users to be well engaged, face-to-face interactions with users are very helpful for introducing them to the tools. Where face-to-face interactions are not possible, closed social media groups can be effective for promotion to the target audience.

The key user groups for agricultural tools are considered to be extension agro-input suppliers and farmers. Reaching these user groups through 'traditional' mass advertising sites is challenging as these groups are more likely to use SMS and locally-based social media digital platforms (WhatsApp and Facebook) to gain relevant agricultural content. In order to try to reach these target users, tailored in-country activities have also been implemented to engage users in ways that are effective in their context. Below are a list of the activities undertaken during the year in different countries

Bangladesh

- Training of 64 master trainers. This led to the scaling up of training and the use of CABI digital tools amongst >6,400 Sub Assistant Agricultural officers, who are the ground-level extension officials in Bangladesh. The objective is to train officials as plant doctors and to establish clinics across the country. The tools promoted included the CABI Academy, the PlantwisePlus Knowledge Bank, the Plantwise Data Collection App, the CABI Bioprotection Portal and the simulator apps.
- Promotion of the horizon scanning tool during a pilot workshop to prioritize a list of invasive species in Bangladesh. There were approximately 25 participants, out of which six were female. Additional tools promoted included the CABI Academy and CABI Bioprotection Portal.

Ethiopia

- Exchange, stock-taking and refresher workshop (May 2022) involving 54 experts and plant doctors. The tools demonstrated and promoted included the PlantwisePlus Knowledge Bank and the Factsheet Library app.
- Support provided on the use of the Data Collection App during workshop and field backstopping visits.
- Training of 20 national experts on pest risk analysis (PRA), which included demonstrations of the PlantwisePlus Knowledge Bank.
- Engagement, exchange, refresher and backstopping workshop (October 2022) for 58 plant doctors and experts. Tools demonstrated included the PlantwisePlus Knowledge Bank and the CABI Academy.

China

- A PlantwisePlus Knowledge Bank user guide produced and added to the United Nations Food and Agriculture Organization's (FAO's) Guide for Training Smallholder Farmers on Digital Literacy (in March).
- Promotion of the CABI Academy to students in the Graduate School of the Chinese Academy of Agricultural Sciences via an online integrated pest management (IPM) course led by Stefan Toepfer (in March), reaching 37 students.
- After an announcement released via the Chinese National Agricultural Library, crop pest diagnosis scholarship provided to 10 Chinese users in May–July.
- After an announcement released via the Chinese National Agricultural Library, crop pest management scholarship provided to 20 Chinese users in September–October.

Bolivia, Peru, Nicaragua, Caribbean

- PlantwisePlus tools and apps promoted in presentations delivered in different symposiums and conferences, via WhatsApp groups involving plant doctors and national coordinators and through social media groups.
- PlantwisePlus tools introduced during training sessions in Trinidad and Tobago, Jamaica, Grenada and Barbados, and during meetings with government representatives.

Kenya

- Plantwise Factsheet App and the Bioprotection Portal promoted to 30 youth during training activities (September 2022).

Nepal

- Simulator apps promoted to extension workers while they were gathered for data management training (December 2022).

India

- Simulator games promoted to stakeholders at stakeholder meetings.

Zambia

- Decision support tools promoted to plant doctors and other plant health experts during field visits and a workshop to update extension materials (November 2022).

Uganda

- Use of the Fertilizer Optimizer Tool by users in Uganda to advise farmers. The tool has been shared in different agricultural platforms to increase its usage.

In order to monitor more closely the uptake of digital tools, a Google Analytics dashboard has been created that gives rapid access to the usage figures. The usage figures demonstrate that in 2022 the PlantwisePlus Knowledge Bank retained its overall user base, with just over 400,000 visits. The usage seen in 2022 has remained consistent with the level of visits in 2021. Promisingly, there was a 7% increase in organic traffic (via search engines), which means that the same number of visits were achieved without the use of paid adverts for the PlantwisePlus Knowledge Bank. This organic traffic is important since it is highly targeted by user intent, but is also driven by SEO. The Crop App Index has had 21,940 visits since it was launched in February 2022, with the largest number of users coming from India. Key PlantwisePlus countries, including Kenya, Pakistan and Ghana, were all within the top seven countries for usage. Most of this traffic has come from paid ads (87%), with only 10% being returning users. The CABI BioProtection Portal had welcomed 1,037,091 visitors by the end of 2022, following its launch in February 2020. There are clear linkages between the development and piloting of digital tools and learning products (Output 1.4.1) and the monitoring of uptake.

The outbreak of the Covid-19 pandemic in 2020 placed additional strain on extension services, leading in many cases to the cessation of extension farm visits. The available literature suggests that governments and other farmer intermediary organizations attempted to bridge this gap through an increased use of digital tools. It was against this background that a research study was undertaken by CABI to investigate the impact of Covid on rural Ghanaian women's digital access to agricultural information (focusing on the use of mobile phones). A case study approach was used, working with communities from the Brong Ahafo region. The research utilized a mixed methods approach, comprising a survey, focus group discussions, and KIs with stakeholders from within the community and the agricultural extension environment. The findings indicate that women's mobile ownership levels have increased since Covid, and usage of phones by women to access agricultural information has shifted considerably, as restricted movement forced adaptations, such as arranging the transportation of crops to market via phone. The impacts of these new mobile phone-based ways of doing business have largely been positive for women – they have reduced costs and time requirements, and have improved women's access to timely information – but they are noted to come with new risks relating to trust and exclusion.

These increases in the usage of phones take place in a context of gendered differences in ownership and usage levels of mobile phones, along with a higher perception among men than among women that mobile phones are a useful tool for accessing agricultural information (in line with previous research). In the study, mobile phones were noted to support transactional information sharing, rather than more complex training in agricultural practices. The impact of a move away from face-to-face extension was not assessed in the study.

Agricultural stakeholders reported ICT-based adaptations in extension practice due to Covid restrictions in order to support farmers, some of which are likely to continue after Covid under an efficiency/effectiveness agenda.

The study's findings provide valuable insights into the significance of digital technologies for agricultural stakeholders. Moreover, they shed light on strategies for promoting gendered access to ensure that women can also benefit from these digital technologies

Evaluation reports

During 2022 a team worked to develop a framework for evaluating the CABI Academy activities. This is based on the Learning Transfer Evaluation Model (LTEM). Using this framework, a set of research questions were formulated, followed by the identification of appropriate data sources. Data was subsequently collected, and synthesized to create a comprehensive evaluation report. The lessons learned from this report will feed into next year's design, development, marketing and evaluation activities.

An assessment was carried out in one target country of the PlantwisePlus programme to understand how the digital tools are used together as one complementary suite. Bangladesh was chosen as the country in which to carry out this assessment as it has access to the range of tools and digital learning courses. The tools assessed included the PlantwisePlus Knowledge Bank website, the Plantwise Factsheet Library app, the Bioprotection Portal, the Pest Diagnostic Simulator, the Crop Management Simulator and the CABI Academy. POMS and the Crop App Index, while not a focus, were also discussed with partners.

The results of the assessment reveal that most users of the PlantwisePlus digital tools are government extension workers and they found out about the tools from trainings conducted by CABI, as well as information shared on WhatsApp and Facebook platforms. The majority of people asked said they use the digital tools to enhance their knowledge, and most of them ranked the reliability of information from these tools as their most important feature. Most study participants had used more than two CABI digital tools and appreciated their complementarity. Language was highlighted as a key limitation to the use of these tools, with users mentioning that they would like the tools to be made available in Bangla. They reported that they would also like the tools to be regularly updated to include the latest information. Inadequate storage space for all of the apps on users' phones was also reported to be a major challenge, and led to some respondents uninstalling the CABI Apps in order to create space for the other tools.

In order to enhance the usefulness of PlantwisePlus tools, it is important to ensure that relevant, reliable and localized content is made available in a language users can understand, preferably in the format of Android-based applications. This content should include high-quality images to aid in pest and disease diagnosis.

Further, users mentioned that they were often confused about the names of the different tools and how to access them, and recommended that the tools be made available in one platform. This is something that it is hoped will be resolved now that the PlantwisePlus Toolkit has been developed.

Hands-on trainings were also reported by the respondents to be useful, especially when rolling out new tools.

Finally, it is necessary to remain responsive to user needs, as this will ensure that these tools remain relevant even in the face of the influx of other similar tools in the digital space.

Next steps

Lack of awareness of tools, the unavailability of relevant agricultural digital content in local languages, the high cost of internet access, and poor internet coverage have been identified as the main barriers to accessing digital tools. Gender disparity in internet access skills and minimal use of digital platforms to procure inputs, access information, and access financial services were also identified as challenges. The next steps will involve attempts to address some of these challenges and barriers in order to maximize the reach of, and engagement with, the digital tools and digital learning courses. Steps include the following:

- Launching the Crop Sprayer app and gathering user feedback for improvements
- Creating marketing messages for each tool within the toolkit
- Producing promotional demonstration videos for each of the tools in the toolbox
- Implementing the findings of the SEO audit of the Crop App Index and the CABI Academy to

improve organic traffic to the site

- Translating promotional materials into key languages for focal countries and considering providing more language translations within tools (e.g. Swahili for the Crop Sprayer app)
- Conducting social media testing and reporting
- Providing country-specific resources
- Developing marketing materials

Implementing in-country promotion activities

Furthermore, the findings of the study into digital access to agricultural information during the Covid-19 pandemic from a gendered perspective will be used to inform a discussion around the changes identified, the impact on gendered access to and use of digital tools, and considerations for extension practice and policy.

Output 1.5: Improved provision of gender-sensitive agricultural extension services

Executive summary

During 2022, a gender and rural advisory services assessment was conducted in Pakistan, and the results were shared with stakeholders in a validation workshop held in Lahore, Pakistan. A similar assessment that was conducted in 2021 in Ghana was also finalized and [published](#). The latter assessment found that there is a strong policy framework and institutional structure for mainstreaming gender in agriculture extension in Ghana, while the former assessment found that there is a weak policy environment and a weak accountability mechanism for mainstreaming gender in agriculture extension in Pakistan. The two assessments identified similar challenges, such as restrictive social norms and difficulties faced by women extension staff in working in the field, in both countries. After validating the assessments, action plans were developed in collaboration with stakeholders in the countries to address the key findings.

To this end, in Ghana, a social learning group of gender stakeholders from the government, academic and non-governmental sectors has been formed. Activities conducted by the social learning group include training 27 national and regional agricultural officers as trainers on, and training 400 district-level extension staff on, gender issues and the use of tools to enhance the gender sensitivity of their work, as well as commissioning an investigative article to explore the limiting factors around women's employment within the extension sector.

Also, in line with the goal of bridging gender inequalities, raising the profile of women farmers and improving their participation in and benefits from agriculture, support was provided for an award that recognizes the best female farmer in the Bono region, at the 2022 Farmer's Day celebrations in Bono.

In Pakistan, the action plan is at an earlier stage of development. The national validation workshop is scheduled to occur in November 2022, before the finalization of the strategy that addresses the recommendations made by the assessment. Given the very different gender contexts within both countries, a different strategy and different activities are required to support the issue of gender within extension, with policy gaps noted as a key issue in Pakistan. However, the social learning approach will be carried through to Pakistan too, with a 'Gender in Agriculture' working group being established to support progress around this issue in 2023.

Progress and lessons learned

During 2022, an assessment on the gender sensitivity of agriculture advisory services in Pakistan was conducted and [a study report was published on the CABI website](#). The assessment was conducted in two districts in Punjab province, one more urban (being closer to the city of Rawalpindi) than the other, and in one district in Sindh province in Pakistan. The aim of the assessment was to identify strengths and gaps in regard to existing agriculture extension systems' ability to reach and benefit both women and men farmers. The assessment covered a review of the national enabling environment, relevant sector policies and institutions, interviews with provincial and district government agriculture extension managers and field staff, and focus group discussions with women and men farmers. It also included interviews with private sector organizations involved in agriculture extension service provision, provincial Women Development Departments, the National Agriculture Research Council, and FAO staff in Pakistan. The assessment identified gaps in the policy and institutional framework, in the organizational culture of extension departments, and in service delivery at farmer level, and it made recommendations for each level. The assessment showed the need to work on an enabling policy environment, to build the capacity of extension staff, as well as to address restrictive social norms in the design and implementation of agriculture advisory programmes. These elements can be incorporated into PlantwisePlus interventions.

The findings of the study were shared with relevant stakeholders in a validation workshop held in November 2022, in Lahore, in Pakistan. The stakeholders included Women Development Departments within agriculture ministries (which it was found were extremely beneficial to engage with), in addition to CABI's traditional partners of extension and plant protection departments, in regard to strengthening the mainstreaming of gender in CABI projects. During the validation workshop participants' views on the findings were sought, alongside ideas on which activities could support the establishment of more gender-sensitive services. Key findings included the following: the need to include gender in annual development plans (through a PC1⁶ proforma for development projects); the need to make gender training for extension staff a requirement, as well as providing budgetary support to enable field-level travel for women advisers; and the importance of academia integrating gender within their syllabus and encouraging agricultural internships at the local level for female students. Following on from the validation exercise, a day was spent sensitizing senior-level representatives on gender issues within agriculture and on shifting thinking to consider the role of women within agriculture and how they can be supported.

In Ghana, a similar assessment was conducted in 2021 and the [report](#) was finalized and published on the CABI website in January 2022. The findings of this study were likewise shared with stakeholders during a validation workshop in Accra in March 2022, involving representatives of the directorates of Agriculture Extension Services, Women in Agriculture Development and Policy Planning, and Monitoring and Evaluation in the Ministry of Food and Agriculture, alongside representatives of agriculture research institutions. The validation workshop helped to identify priority advocacy agendas, and a multi-stakeholder social learning group was established to oversee and support the steps towards implementation of these agendas.

The assessment in Ghana showed that there is a strong policy environment and organizational structure for mainstreaming gender in agriculture extension. This is not the case in Pakistan, where the policy framework is weak and where there is no accountability mechanism for mainstreaming gender in agriculture extension. In both countries, increasing the number of women extension agents is seen as key milestone for improving women farmers' access to advisory services. However, working conditions, transportation problems, security challenges and a lack of public affordable child care facilities for extension staff affect recruitment and retention of women extension agents in the two countries. Social norms are the main barrier to women's lack of access to extension advisory services in both countries. The need to build the capacity of extension staff and managers on gender-sensitive extension approaches was also identified in both countries. In both countries, follow-up advocacy, communication and capacity building activities will be informed by the lessons drawn from the assessment.

In Ghana, a two-day [training](#) was conducted in Kisumu, for staff from the Extension Services, Plant Protection and Regulatory Services, and Women in Agriculture Development departments of the Ministry of Food and Agriculture across six regions. In total, 26 people (11 women and 15 men) were trained on

⁶ A PC1 proforma is a document used by the Government of Pakistan to plan and budget for development projects. It is a comprehensive document that includes information on the project's objectives, scope, cost, schedule, and implementation plan.

the provision of gender-sensitive agriculture extension services. The training covered topics such as the basic concepts of gender, the importance of looking at gender in the agriculture sector, basic gender analysis tools that can be used by agriculture extension agents, and strategies to reach women farmers with agriculture extension service provision. Feedback from the training was overwhelmingly positive, with participants reporting that the tools had opened their eyes to the different roles and responsibilities of women within the rural context, and how this may affect their ability to engage with extension services.

Directors of Agriculture of the target regions and districts also embraced the training content fully and promised to ensure that the trained officers integrate this in their work. In addition to this, an investigative article was commissioned into the barriers to women's participation within extension, in order to spark dialogue around this issue. A study is being conducted to identify constraints in the implementation of a gender policy within agriculture, and a workshop involving extension stakeholders took place in October on best practices for gender-sensitive ICTs within agriculture. Finally, a social and behaviour change campaign is being planned which will seek to foster dialogue around women's roles within agriculture, and shift perceptions about who extension 'clients' are and how women can participate more actively, for the benefit of all.

Next steps

During 2023, activities will continue in both Ghana and Pakistan, responding to the recognition that influencing the gender sensitivity of national extension services requires a number of changes at both social, policy and organizational levels, which will undoubtedly require sustained efforts over the medium to longer term.

For Ghana, activities will include the implementation of the social and behaviour change campaign, the development of a handbook on gender within agriculture aimed at extension staff, as well as a continuation of the already initiated activities on training and policy implementation.

For Pakistan, a communication strategy is in development and the following activities will also be conducted:

1. Development of a gender strategy for two provinces, working with the Department of Agricultural Extension and in partnership with the Women's Development Department, FAO and the National Agricultural Research Council
2. Constitution of a multi-stakeholder Gender in Agriculture working group to action priorities as identified by the study
3. Supporting the development of a curriculum on Gender in Agriculture aimed at extension officers and field assistants in two provinces
4. Initiating social and behaviour change campaigns in two districts, including supply-side activities (extension) and social and behaviour change interventions (e.g. interactive theatre). These will be pilot activities aimed at learning what works, with a view to scaling up to other areas

In addition, it is planned that assessments on gender and access to digital advisory services will be conducted in two new countries, based on the dissemination of digital tools developed by CABI under the PlantwisePlus project. This will provide additional insights into best practices for delivering information digitally to women farmers and extension workers, and will ensure that the programme is aware of, and able to address, any issues related to a gender digital divide.

Annexes

- [Gender and rural advisory services assessment in Ghana](#)
- [Gender and rural advisory services assessment in Pakistan](#)

PlantwisePlus Specific Objective 2: To increase supply of safer food through enterprises driven by women and youth to meet growing demand by consumers in rural, urban and peri-urban markets

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Output 2.1: Domestic demand for safer produce increased

Executive summary

A social and behaviour change strategy has been co-developed with a wide range of stakeholders and will be implemented during 2023 using a range of communication and complementary approaches. The campaign aims to fill knowledge gaps on pesticides, to change perceptions of the risks of pesticides if these are not selected, applied and disposed of in the correct manner, and to influence pesticide use behaviours. The campaign will initially be implemented in Nakuru County in Kenya, with the possibility of scaling to other counties in the country. The strategy design was preceded by a formative appraisal being completed in the county, as well as a behaviour change prioritization workshop. Target behaviours include farmers safely using pesticides to minimize health risks to themselves, other people and the environment, and farmers providing markets with safe produce that has acceptable (or zero) pesticide residue levels. The campaign will focus on pesticide risk reduction in general, as well as particularly in regard to issues relating to tomato production, given that tomatoes are frequently sprayed, have been identified as a crop on which residues are found in markets, and are widely grown and consumed in Nakuru.

Progress and lessons learned

Assessment of pesticide residues

In 2022, CABI and its partners gathered data on pesticide residues, to provide evidence of risks within agricultural value chains. During the year, CABI signed work and funding contracts with public institutions that are active in food safety research and leading national residue monitoring programmes in Ghana, Kenya and Pakistan, in regard to collecting and testing pesticide residues. In each country, tomato was selected as the initial focal crop because it is an important cash crop and there is a tendency to apply high amounts of pesticides to it, in terms of the number of active ingredients, and the number of applications and dosages. In each country, tomato samples were collected from multiple tomato-producing regions and analysed for 30 or more different pesticide active ingredients.

In Ghana, 105 samples have so far been analysed for 38 active ingredients, by the Food Research Institute (FRI) which is one of the thirteen affiliate Institutes and Centres of the Council for Scientific and Industrial Research (CSIR). Preliminary results show that 17 active ingredients were detected in the samples, with the levels of three active ingredients exceeding the maximum residue limit (MRL) specified by CODEX. The most commonly detected pesticide residue was Carbendazim, present in 34% of the samples analyzed. Acephate was detected in 21.9% of the samples analysed, with Acetamiprid (16.2%), Chlorpyrifos (29.5%) and Metalaxyl (7.6%) also detected. The highest Carbendazim concentration of 1.58 mg/kg recorded for fresh tomatoes was far above the MRL of 0.50 mg/kg specified by CODEX. The highest mean concentration of 3.82 mg/kg was obtained by Difenconazole and was far above the MRL of 0.50 mg/kg specified by CODEX. The highest Chlorpyrifos concentration of 1.135 mg/kg recorded for fresh tomatoes analysed was far above the MRL of 0.50 mg/kg specified for fresh tomatoes by CODEX. A previous study⁷ in Ghana had reported Chlorpyrifos concentration in the range 0.044 to 0.524 mg/kg for fresh tomatoes sampled from Kumasi, which was far lower compared to the highest Chlorpyrifos concentration of 1.135 mg/kg recorded for fresh tomatoes in the present study. The differences between

⁷ Darko, G. and Akoto, O. (2008) Dietary Intake of Organophosphorus Pesticides Residues through Vegetables from Kumasi Ghana. Food and Chemical Toxicology, 46, 3703-3706. <https://doi.org/10.1016/j.fct.2008.09.049>

the Chlorpyrifos concentration reported by Darko and Akoto (2008) and the concentration identified by CSIR-FRI may be due to the use by farmers of a higher dosage of pesticide than is recommended.

In addition, the multimedia production unit of the Directorate of Agricultural Extension Services in Ghana was engaged to work with CABI and the Plant Protection and Regulation Services Directorate (PPRSD) to collect video footage and photos from various tomato production fields, in order to provide audio-visual evidence on pesticides use practices among various actors, to contribute to meaningful stakeholder engagement and awareness raising.

Value chain risk analyses is planned, as well as the engagement of stakeholders, once the findings of the residue analyses are complete. These will form part of the 2023 activities. The aim is to obtain enough evidence on pesticide residues to plan who and how to engage the relevant stakeholders. Further collection of samples of other important crops will be undertaken in 2023 in Ghana, Kenya and Pakistan.

In Kenya so far, 79 tomato samples have been collected and sample extraction, analysis and reporting will take place after the sample collection has been completed, possibly spilling into 2023. This setback was occasioned by delays in finalizing the work and funding contract with the partner.

Consumer perceptions

During the year, consumer surveys were conducted in Ghana and Pakistan, with the aim of determining the relative concerns of consumers regarding pesticide residues, contaminants, and other food safety issues, and policy and communication strategies for reducing food safety risks. The results of these surveys are an important input in the implementation of national stakeholder engagements and civil society-driven advocacy and food safety behaviour change campaigns.

In Ghana, 1,634 consumers were surveyed, drawn from key production areas and major produce distribution markets in seven strategically selected regions across the country, while in Pakistan, 1,839 consumers were surveyed in six regions. The respondents were sampled from among key actors across the food production and distribution chain. In both study countries, food safety risks were associated with poor food handling practices at various levels and a failure of producers to observe pesticide pre-harvest intervals. The location, occupation and socio-economic characteristics of consumers affected their awareness of, and concern with, various food safety issues, which is attributed to factors such as access to information sources and ability to understand information, as well as the risk associated with direct exposure to food safety risks (e.g. pesticide use). Food safety risks exist at different levels, which are often beyond the control of consumers, and awareness of such risks is varied, which necessitates understanding behaviours before embarking on a communication campaign. The multidisciplinary nature of food safety requires strategic partnerships with other sectors, such as public health and environmental organizations, for a more holistic approach.

Awareness and advocacy campaigns

Through the PlantwisePlus programme, CABI works with partners to design and implement campaigns to raise public awareness in order to ensure safer, higher-quality and locally produced food. Based on the findings of previous studies including, the 2021 situational analysis, consumer surveys, and a desk study into pesticide residues found on domestic crops in Kenya, a social and behaviour change approach was identified as the most appropriate way to address the multi-factor issues affecting the purchase, use and disposal of chemical pesticides, involving a number of stakeholders from the private sector through to smallholder farmers and consumers. From pesticide residue data for Kenya (as well as KILs), it was identified that tomatoes have high levels of pesticide residues, are a frequently sprayed crop, and are commonly grown and consumed by the domestic market across Kenya. These factors suggest this is an issue that could be addressed through a social and behaviour change campaign. This has led to the selection of the tomato value chain/crop, and the county of Nakuru (a major tomato-growing region in Kenya), as the focus of a pilot campaign.

During 2022, CABI worked with the Department of Agriculture in Nakuru County to undertake a formative assessment to gather information on the key stakeholders, issues on the ground, practices of farmers, and opportunities for and barriers to change. This formed the basis of planning for a participatory stakeholder strategy development workshop, which aimed to identify key behaviours, audiences, information needs and appropriate channels for an intervention strategy. The workshop was attended by food safety, public health, private sector, extension and farmer representatives, with the intention being that the strategy would be owned by the County Government of Nakuru, and that the portfolio of activities would be supported by a collaboration of stakeholders, rather than just by CABI. Subsequently, a behaviour communication strategy was developed. Based on this strategy, a behaviour change campaign will be launched in 2023, with a focus on the farmer at the centre – as it is farmers who purchase, apply and dispose of pesticides.

Next steps

A key next step is to continue testing pesticide residues, taking more samples within the same or another value chain, as prioritized in the given country. In addition, an Hazard Analysis and Critical Control Point (HACCP) and stakeholder engagement will be undertaken on pesticide risks along certain value chains (in Kenya, Ghana, Pakistan and Bangladesh).

Finally, a behaviour change intervention will be launched, involving mass communication and engagement of policymakers, on pesticide risk reduction and other food safety issues, such as mycotoxins (in Kenya, Ghana and Pakistan).

Output 2.2: Farmers working to a voluntary crop production standard to deliver safer, environmentally friendly produce to higher-value markets

Executive summary

Assessments were carried out in Ghana and Kenya to identify relevant standards that could benefit from the input of CABI. The goal was, to either strengthen their support to farmers or expand their reach, encouraging more farmers to adopt these standards. By doing so, the aim was to reduce their reliance on pesticides. Two standards were identified in this regard: Ghana Green Label standard GSA (GS 1054 and GS 1074): A food safety certification scheme; and Kenya KS1758: Fruits and Vegetables code of practice. CABI supported the delivery of training on these standards to 226 agricultural extension agents and trainers in Kenya and Ghana, and 100 implementers in Kenya. CABI also started working with Green Label to improve their overall training landscape, starting with a 360-degree audit to identify areas for improvement. Recognizing that the adoption of standards is driven by market demand, Green Label and CABI are collaborating with Eden Tree, a local fresh food off-taker, to form groups of farmers who will be trained to comply with the standard, and to develop their skills to improve the relationship between buyer and seller so as to build loyalty and trust, thereby sustaining the adoption of the standard.

In addition, in China and Vietnam, CABI explored opportunities for supporting the Kiwi industry, and rice and vegetables, respectively.

Progress and lessons learned

Barriers to, and opportunities for, farmer compliance with production standards

Assessments in Ghana and Kenya identified standards that could benefit from CABI's input to either strengthen support for farmers, or expand their reach. Ultimately the aim was to encourage more farmers to adopt standards that reduce reliance on pesticides. An assessment to identify suitable value chains for activities in 2023 was also undertaken in China and Vietnam.

In Ghana, CABI worked with Green Label Foundation to support implementation of Ghana Green Label standard GSA (GS 1054 and GS 1074): A food safety certification scheme, following prior discussions with the Foundation. Key areas of intervention were jointly identified and a work plan was put together, particularly focusing on training trainers, developing training materials, and the certification of producer groups.

In Kenya, an assessment showed that there are various internationally and locally known food safety standards, and certification for these standards is fast becoming compulsory and is demanded to showcase the practice of good agricultural methods in all sectors of food production. Some standards like Kenya gap, HACCP, CODEX and the MRL are well-known to, and applied by, farmers targeting fresh produce like French beans, baby corn, snow peas etc., for the export market. The Kenya Plant Health Inspectorate Service (KEPHIS) and Kenya Bureau of Standards both facilitate the CODEX Alimentarius standards for fresh produce for international markets and final products for the global market, respectively. The Kenya KS1758: Fruits and Vegetables code of practice, first launched in July 2017 by Kenya's cabinet secretary as the "horticulture quality mark 'KS 1758'" was re-launched in 2021. Currently, a limited number of companies, mainly those that are exporting and therefore already comply with GLOBALG.A.P, are registered and have been audited. This is partly attributed to the high cost of certification that producers are not ready to incur where there are no guaranteed returns in the local markets, the fact that consumers do not demand these standards (probably due to lack of awareness), and the lack of a body to enforce use of these standards to ensure the safety of local consumers.

CABI identified this standard since it is mandatory, and identified areas of support that could be provided to the Standards Implementation Committee, in line with these identified challenges. Discussions have been initiated with the Horticultural Crops Directorate of Agriculture and Food Agency and the secretariat for the Standards Implementation Committee, in addition to supporting already ongoing activities by Fresh Produce Consortium Kenya (FPCK).

The KS1758 standard seems to focus more on large-scale producers and is likely to lock smallholder holder farmers out of business, considering that the government has made it compulsory. This offers a good entry point for intervention by CABI in the areas of advocacy and facilitation of the standards review process to ensure the needs of smallholder farmers are catered for.

For more impact, CABI needs to diversify its partnerships: for example, partnering more with government agencies that are pushing the KS1758 agenda and establishing strategic partnerships with the private sector to achieve specific well-defined objectives.

In China, the fresh produce industry is heavily regulated, with standards in place for most crops. An assessment was therefore undertaken to identify a suitable value chain where farmers are having issues with pesticides. Another consideration was also identifying a value chain in relation to which CABI already conducts activities. The intention is for PlantwisePlus to add value to existing work, to multiply impact and optimize limited resources. Kiwi was selected as a potential value chain. China had limited budget assigned to this output in 2022, and so information gathered was used to inform a programme of activities for 2023.

In Vietnam, an initial assessment was made of the potential areas that CABI could work on in the country. In the Mekong Delta, reports of issues of pesticide use in rice and vegetables have been identified by the provincial government. The Mekong Delta is a fragile landscape, with changes in the climate resulting in limited rains feeding the Mekong river at certain times of the year, leading to salinization of the soils in the Delta. This is impacting the production of food in the area, driving farmers to use more fertilizers and pesticides. The provincial government is keen to transform the agriculture sector to mitigate the risks of climate change. Initial conversations with officials were followed in November with interviews with the farmers and local stakeholders, and information gathering, in order to propose activities in 2023.

Smallholder farmers often find themselves “locked out” of lucrative markets due to a lack of economies of scale, low awareness of market demand, a lack of sufficient knowledge about production standards that need to be applied to meet market demand, and poor infrastructure leading to high traction costs⁸. Where farmers organize themselves into groups, this creates many opportunities to overcome these challenges. By enabling farmers to work together to reliably meet the demands of a particular market actor, the costs of production can be reduced and the provision of training and support can be more efficient. In this vein, a detailed farmer group study is planned to link in with the work on standards in Ghana, Kenya, Vietnam and China. The purpose of the study is to understand the various characteristics of different farmer groups and what influence they have on the functioning of that group; and what attributes of those characteristics directly determine the nature of the relationship with a buyer, with the aim of facilitating access to lucrative markets and improving the production of safer, quality food through the adoption of the standards.

During 2022, a literature review on the effectiveness of farmer groups was undertaken in Kenya and Vietnam, and data collection tools were developed and tested in Kenya, Ghana and Vietnam. Insights from the testing of tools in Ghana with the Michel Camp farmers, who have previously been trained on Green Label, show that their engagement and negotiation with Eden Tree was an area of weakness for them. This is leading to mistrust in the relationship. Additional training will be given to the groups, alongside technical training, to improve the understanding of their business and what their “ask and offer” is when they engage with Eden Tree.

CABI also worked with various off-takers to build buyer–seller relationships to create market demand, and therefore drive standards adoption. Eden Tree was identified in relation to forming groups of farmers who will be trained to comply with the standard. A group of 20 farmers were brought together who are currently supplying Eden Tree with a range of products. A workshop was held to understand the situation with the farmers in relation to their relationship with Eden Tree, to discuss issues relating to market and business, and to discuss the benefits of being in a group to overcome challenges. The participants were then invited to form a group, after which they will be trained by Green Label and CABI to achieve the Green Label standard, and later certified, once a contractual relationship had been established.

8 ILO (2017) Addressing governance challenges in a changing labour migration landscape. Geneva: ILO

Enabling farmers to meet voluntary production standards

Working with partners in Ghana and Kenya, CABI aims to support farmers to meet voluntary production standards and access higher-value domestic markets. In Ghana, a review of Green Label training materials was conducted, particularly focusing on enhanced modules on crop management. In line with this, existing Plantwise Pest Management Decision Guides – “Green and Yellow” lists for selected pests in vegetable production were reviewed and compiled as pest management reference materials for growing safer produce, to supplement the Green Label Farmers’ training manual. The Pest Management Decision Guides will be used to train farmers and agricultural extension agents as part of Green Label standard training sessions. Training of agricultural extension workers as trainers was also carried out, with at least 106 agricultural extension workers trained on all 10 modules of the Green Label standard, the use of Pest Management Decision Guides, and the use of plant protection products. A 360-degree training audit is underway to identify areas for improvement in the Green Label training programme, and to pave the way to creating strong training programmes and a foundation for introducing new innovative approaches to training, such as the use of ICTs, e-learning, and continuous development programmes.

In Kenya, CABI supported the training of 120 trainers on KS1758. The training was delivered by FPCK. The trainers included different vegetable and flower exporters in Kenya. The trained exporters are now expected to train producers who grow the produce for them. All the represented export companies are members of FPCK and this training on KS1758 was meant to familiarize them with the Kenya standard and to identify areas that are either similar to or different from GLOBALG.A.P, a standard that they use for the production of fresh produce for the export market.

Market assessments and stakeholder meetings were held in Nakuru and Makueni counties involving County Directors of Agriculture, the Ministry of Health, KEPHIS and the Agriculture and Food Authority (part of the Horticultural Crops Directorate), the Department of Trade, the Department of Agriculture, FPCK, and CABI. The activity focused on possible collaborations in training different key actors along the value chain on food safety and KS 1758 standard, complemented by visits to markets to assess the market status in regard to compliance with food safety standards and to identify existing efforts by the Food Safety Committee to avoid duplication. The market assessment revealed various other efforts on the ground that CABI can leverage for greater impact. For example, the County Government of Nakuru has initiated several strategies that support food safety: passing the Nakuru Health and Sanitation Act and Food Policy (in process), pesticide risk training, several sensitization trainings on KS 1758 standards and solid waste management, and the presence of KS1758 standard trainers. Mango and vegetables were identified as suitable value chains, to align with other PlantwisePlus activities. Subsequent to this, a one-day sensitization training of 100 implementers (market actors, county government staff and extension workers) was undertaken in Nakuru, focusing on various aspects of KS1758: traceability, record-keeping, plant nutrition and pesticide use, and post-harvest handling.

The original activities under Output 2.2 did not reflect the need in the market highlighted during the initial scoping work. Adjustments were therefore made to the workplan to fill identified gaps in knowledge, and to support the adoption of existing standards, rather than creating new ones. As such, Activity 2.2.2: Develop an achievable voluntary production standard relating to safer food, was dropped.

Work with the Green Label and KS1758 standards, and collaboration with buyers and farmer groups, provide a “cluster”, to which other activities can be linked. For example, with Eden Tree in Ghana, there is the possibility of undertaking a pesticide risk assessment of their supply chain to help them identify areas of risk, and also improving their pesticide residue analysis protocol. This would provide more targeted testing during more appropriate times when there is high risk. Communication activities and service provider training can also be linked to identified common interest groups to enhance impacts.

Next steps

Capacity building of partners in relation to Ghana Green Label and Kenya KS1758 will be continued, targeting the capacity gaps identified, so that farmers are better equipped to comply with the identified standards.

Output 2.3: Job opportunities for young men and women in rural communities to provide agricultural services to local producers

Executive summary

Partnerships have been established with various agribusinesses to skill service providers, particularly youth and women:

1. Zirowe Agaliawamu Agri-business Training Association (ZAABTA) is a rural agribusiness initiative in Uganda that operates an aggregator-driven model whereby services are facilitated by producer or aggregator and payments are mediated by agro-dealers. ZAABTA works with around 1,036 youth through their Nokia Youth Support Services along agricultural value chains. In 2022, CABI worked with ZAABTA to identify areas of support and to deliver trainings, particularly to youth and women, to enhance their skills in agricultural service provision and enhance their job prospects.
2. Green Label Ghana Foundation is a public-private-partnership initiative started by the Ministry of Food and Agriculture, working with GIZ and Ghana Standards Authority, along with other partners, including GhanaVeg (now HortiFresh), Christian Aid, Agro-Eco, the Food and Drug Authority, and Quin Organics. Green Label had previously been in conversation with CABI to support the implementation and adoption of the Ghana Green Label standard. During 2022, CABI worked with Green Label to support implementation of the standard, particularly the training of trainers, the development of training materials, and revision of Plantwise Pest Management Decision Guides in line with the requirements of the Green Label standard.
3. FPCK is the leading trade association committed to driving the growth and success of fresh produce companies and their partners in Kenya. FPCK comprises producers, traders, and service providers involved in Kenya's fresh horticultural produce. FPCK is part of the Standards Implementation Committee for the KS1958 standard. In 2022, CABI worked with FPCK to deliver trainings to trainers on the standard.
4. Micro Enterprises Support Programme Trust Kenya approached CABI to explore potential areas of collaboration, recognizing the complementary skills and opportunities for multiple impact that could be achieved by working together.

Progress and lessons learned

Building the capacity of young men and women as agricultural service providers

This activity targeted unemployed young men and women, or those already participating in previously identified rural employment initiatives, with basic agricultural knowledge. The intervention was delivered in Uganda, Kenya and Ghana, with a total of 363 (male 277, female 86, <35 years 130) participants taking part in training on various topics relating to agricultural service provision: IPM, safe pesticides handling and application, spray service provision, and plant health diagnosis and recommendations (based on Plantwise plant doctor training) and training on standards. The trained service providers are already working in agricultural service provision, either as farmer trainers or providing farmer linkages to inputs, operating agro-dealerships, providing spray services or giving plant health advice linked to various farmer groups. Others are working as farmer service centres – an intervention of the Farm to Market Alliance (FtMA) that involves a service provider giving a range of inputs, services, information, finance, technology and market connections that help farmers participate in market-driven agricultural economies. This skilling and linkage of various service providers has provided an opportunity for those who have received training to achieve income generation in various areas. Besides training new service providers in the coming year, those trained this year will be followed up and backstopping will be provided to ensure they provide quality services to smallholders and also ensure sustainable linkages for their businesses.

The trainings in Uganda were delivered in partnership with ZAABTA, involving trainers from the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) and Makerere University, who also offered certification for the safe use training that allows for the establishment and/or sale of agro-chemicals. In Kenya, the training was delivered in partnership with FPCK, Koppert Biologics Limited and the Agrochemical Association of Kenya. In Ghana, this was done through partnership with Green Label.

The training in Kenya and Ghana was beyond the original scope of the agricultural service providers but was accepted by the partners because it provides opportunities for agricultural service provision and income generation for women and youth as well.

Testing business models for employment opportunities relating to producer-oriented service provision

Building on a literature review on business models conducted in 2021 that identified various models for engaging youth, an in-depth analysis of selected models was carried out in 2022. The assessments specifically focused on understanding the kinds of agribusinesses operated by women and youth that can be built into business cases to be tested and piloted for future upscaling under PlantwisePlus. The results showed that youth (men and women) are engaged in viable agri-businesses that provide services to farmers, with some of the key lessons being as follows:

- cash-for-advice model is not viable as farmers are not willing to pay for advisory services, given that they can get advice free of charge from government officials and agrochemical companies
- some youth are employed on a salary model by co-operatives to provide advisory services to their members
- commission on sales of recommended inputs and on aggregated produce is a successfully tried and tested model in Nakuru County and could be replicated elsewhere, with improvements in areas such as sound diagnosis and recommendations
- cash-for-spraying services is an agribusiness model that can work and, if done properly, could contribute to safer food; however, a lot of work needs to be done to ensure that the spray service providers achieve the desired outcome of reducing the risks relating to pesticide use – currently the model has serious challenges that prevent it from achieving this objective
- some youth are also setting up agro-input businesses to serve groups of farmers whom they train and give advice to

Based on these results, the Farmer Agribusiness Facilitation Service (FAFS) model was piloted in Nakuru County in Kenya. The FAFS model broadly includes the following along a value chain:

- Production: provide farmers with technical advice on what to grow, how and when to grow it, what inputs to use and how to apply them, how to manage pests and diseases, and when and how to harvest. Farmers will not pay for this service directly but there will be a marketing avenue for the FAFS providers.
- Post-production: information on how to manage produce after harvest, covering processing, packaging, storage, aggregating produce for collective marketing and finding buyers for farmers' produce.
- Business planning and marketing: training farmers to engage in farming as a business, provide marketing information and financial analysis of costs and benefits.
- Organization: Training and facilitating farmers in regard to forming groups, organization functioning, collective marketing, group leadership and dynamics, record-keeping, etc.
- Brokering services: forming or activating dormant farmer groups, linking farmer groups, and brokering deals between farmers and other actors in the value chain, such as buyers, input suppliers and agri-finance providers.

The piloting of this model included the selection and training of 32 youth in spray service provision, pest diagnosis and IPM, and building linkages to enable the promotion of lower-risk pest management products. The trainings were delivered in partnership with Koppert Biologics Limited and the Agrochemicals Association of Kenya.

Next steps

The skilling of service providers, in particular women and youth, will be continued, alongside linking them to farmer groups for income-generating opportunities.

Monitoring and backstopping of the youth trained in the FAFS model pilot will be conducted, to ensure service providers' compliance with contractual quality assurance requirements.

PlantwisePlus Specific Objective 3: To strengthen systems for detection and response to pest outbreaks

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Output 3.1 Co-ordinated pest preparedness, prevention and management through the use of the newly established decision support system

Executive summary

In 2022, monthly pest insight reports, each featuring around 40 prioritized pests, were provided for Ghana, Kenya, Zambia and Burkina Faso. The most frequent updates were on new pest reports/change of distribution. Feedback from national plant protection organizations (NPPOs) indicated that the reports are useful and have triggered changes to risk management. To reduce the cost of subject matter experts reviewing the information, a proof of concept using machine learning to filter raw information is being conducted. A human-centred design approach is also being tested to understand the NPPO context for pest insight reporting and other pest risk-related activities. This has already confirmed that capacity development in relation to understanding risk is needed to make full use of the various tools.

A further follow-up survey was carried out during the year to assess the impact of the biocontrol agent *Acerophagus papayae* on papaya mealybug populations. A key learning from this survey was that a longer period between biocontrol agent mass releases and follow-up surveys is recommended to enable a clearer assessment of any change that might have taken place. In 2022, we also conducted a monitoring, evaluation and learning study to evaluate farmers' perceptions of adopting conservation biocontrol to control fall armyworm (FAW), and their willingness to do so.

During the year, CABI tools and general methods for horizon scanning and pest risk analysis (PRA) continued to be demonstrated in specific PlantwisePlus workshops in Kenya, Zambia, Ghana, Burkina Faso, Bangladesh and Pakistan. The prioritization of potential invasive plant pests has been completed using the horizon scanning tool in Zambia, Burkina Faso and Pakistan, and has been initiated in Bangladesh. In Kenya and Ghana, over 40 full PRAs, both pest-initiated and pathway-initiated, have been conducted and the process is now fully integrated in national plant protection activities. Surveillance activities to support the horizon scanning were undertaken on banana bunchy top (BBTV) and Asian citrus psyllid in Ghana, and on citrus canker in Kenya. PRISE has continued to provide farmers in Kenya, Ghana, Zambia and Malawi with early-action pest alerts. Fieldwork for PRISE modelling of beanfly was undertaken in Kenya, and a significant piece of work on further analysing PRISE impact was undertaken, with results expected in 2023.

Progress and lessons learned

Developing an insight reporting system for plant health threats

To assist NPPOs to conduct more structured horizon scanning and risk analysis, CABI generated a total of 20 pest insight reports during the year. These reports are prepared by regularly web-scraping/searching multiple sources of pest and disease outbreak information and synthesizing this into a report to raise awareness of new pest developments and to guide countries in evaluating the level of risk to each of them.

An extended insight reporting pilot was carried out in 2022 in Ghana, Kenya, Zambia and Burkina Faso. A number of pests have been included on more than one of the pest lists, and are therefore likely to be pests of greater significance or concern. 18 species were included on the pest lists for two countries, and three species (*Spodoptera eridania*, *Thrips palmi* and cassava brown streak viruses) were included on the pest lists for three countries. A total of 150 articles were selected for inclusion in the pest

insight reports sent between May and September to the four countries. Two species were consistently represented in selected articles in each of the five reporting months: *Meloidogyne enterolobii* and *Alternaria alternata*.

A review of the number of articles of each type that were selected about each pest species showed that more than 50% of selected results fell into the “first report / change of distribution” category. This category also accounted for the majority of the results for each country. The “non-compliance” and “policy” categories contained the fewest results, with none being selected for inclusion in any of the reports that were sent to the NPPOs. The results of this review may be used to inform future source list updates.

Throughout this pilot, the use of different input methods has been valuable both in terms of best capturing the available information of value to NPPOs, and in terms of learning the relative pros and cons of each. Some of the feedback from NPPOs resulting from the insight reporting includes the following: insight reporting contributes to awareness, early detection and developing detection protocols; there is a need to intensify surveillance at the borders to monitor pests and vectors; there has been reclassification of some low-risk pests as high-risk, with the need to undertake PRA based on this new classification.

As part of this activity, Ghana and Zambia participated in an initial pilot on using the human-centred design (HCD) approach for risk assessment and mitigation.

In the short to medium term, it is unlikely that there will be opportunities for generating income from insight reporting or related services, which could have been a mechanism of sustainability for the service. Therefore, there is a need to scale and sustain this activity in other ways. There will also be a need to find ways of reducing the number of information items that need to be considered by the pest “experts”, and for which they need to provide insights.

The more intensive interactions with NPPOs confirm the impression that insight reporting is essentially a new activity. Initially, this work was expected to be more around narrower issues of user experience and the presentation of insight reports, but it has become clear that increasing understanding of the broader context for insight reporting is necessary. Thus, the planned user experience work was adapted, and restricted to Ghana for the more formal HCD approach, to see what outcomes could be achieved with an HCD approach. From this exercise, it is apparent that the concepts of risk and risk mitigation in respect of pests that are not yet present in a country is unclear. The notions of risk and risk management with regard to managing well-established pests, and supporting exports, appear to be mixed up. Thus, more work is required to build capacity in NPPOs not only on the mechanics of undertaking risk assessment, but on the overall concepts of risk-based approaches in preventing the introduction and establishment of new pests.

Understanding the social impacts of pest control practices

A knowledge, attitudes, behaviours, and practices survey undertaken in Kenya on papaya mealybug (*Paracoccus marginatus*) showed that there were low levels of awareness of biological control among farmers. Farmers were found to lack knowledge, experience and technical support from extension or agro-dealers. However, farmers expressed high levels of interest in biological control, and willingness to support this, and were willing to reduce their chemical pesticide use to help conserve and support the establishment of natural enemies. The next steps in this area include targeted awareness-raising, capacity building, and effective information dissemination.

The surveys on papaya mealybug in Kenya required advanced engagement with county agricultural officers and lead farmers in the survey localities. In future, earlier engagement with communities and the identification of separate groups to take part in focus group discussions is recommended. Ongoing engagement with communities would help to promote good relations and subsequently might help in the identification of particular groups of farmers. In addition, consideration should be given to the timing of surveys: for example, the apple snail survey coincided with the bird scaring stage and farmers were not willing to sit for a long time, for fear of losing more of their crop.

The socio-economic assessment of apple snail (*Pomacea canaliculata*) in Kenya highlighted that households observing at least a moderate level of apple snail infestation (more than 20% of cultivated area) experienced significant reductions in rice yield (~14%) and net rice income (~60%). The cost of hired labour for the physical removal of egg masses and adult snails is resulting in substantial negative effects on net income. The results from the invasive apple snail (IAS) work have fed into communication campaigns alerting communities to the spread of, and how to manage, apple snail in Kenya.

A monitoring, evaluation and learning survey was also conducted in Zambia to understand the perceptions, attitudes and willingness of farmers in relation to co-ordinating collective pest management for the highly destructive FAW and the knowledge acquired during the project on biocontrol and FAW. The main factors limiting communities in regard to co-ordinating actions for FAW management were found to be a lack of knowledge on how to co-ordinate such management (they were not aware that it was an option, as compared to field-by-field management), a lack of finances, poor co-ordination among farmers, a lack of co-ordination, and inconsistent climatic patterns. Nearly 69% of respondents declared that insufficient incomes was the most limiting factor in regard to planning for long-term pest management.

Drawing on these social impact activities, two papers were submitted for publication: one on farmers' knowledge, attitudes and practices towards biological control of papaya mealybug and the other an assessment of the socio-economic impact of the IAS on smallholder rice farmers.

Preliminary analyses from the monitoring, evaluation and learning survey on conservation biocontrol showed that the project had a significant impact on farmers' ecological knowledge regarding biocontrol, the FAW cycle and the identification of stages, as compared to other common maize pests in Zambia, the identification of natural enemies attacking FAW, and how they control FAW in the field. Participants involved in the project scored higher on ecological knowledge than non-participants. When asked about the limitations in regard to implementing or upscaling intercropping, participants named the main limiting factors as lack of knowledge, lack of inputs or finances, that the process is very manual, that it is not compatible with other farming management practices, and that it is labour intensive. The report on conservation biocontrol has been completed, with a journal paper to be submitted in 2023.

Horizon scanning and PRA for plant pest preparedness

In Kenya, 15 pest-initiated PRAs were completed on species that had been selected following a horizon scanning exercise. Work on a new set of 20 PRAs, both pathway- and pest-initiated, was also initiated. Performing PRAs for import control and trade has been adopted as part of the workflow for the Kenya NPPO, KEPHIS.

In Zambia, the horizon scanning activity completed the assessment of prioritized pest threats (53 bacteria, 4 chromista, 26 fungi, 177 insects, 10 molluscs, 37 nematodes, six protista, 101 vectors and 31 viral species), and this will be published in 2023, when actions will also be undertaken to mitigate against them.

In Ghana, PRAs were conducted on two pests considered as priority pests for Ghana: *Callosobruchus chinensis* (Chinese bruchid) and *Brevipalpus phoenicis* (false spider mite). As an outcome of this exercise, Ghana's NPPO constituted a PRA team to review the country's quarantine pest list using the CABI PRA tool and to continue to use the tool in future PRAs to ensure that every PRA conducted is reliable and phytosanitary measures recommended are scientifically justified. Following on this outcome, another seven species were selected for a PRA: the nematodes *Meloidogyne enterolobii* and *Meloidogyne hapla*; BBTV virus; and the insects *Diaphorina citri*, *Rhynchophorus ferrugineus*, *Maconellicoccus hirsutus* and *Aleurothrix floccosus*.

In Burkina Faso, the prioritization of potential invasive plant pests based on the CABI horizon scanning tool developed a list of 87 arthropods, 89 pathogens and 15 nematodes. Following the expert assessments, the 20 most harmful insect species and plant pathogens were prioritized for PRA, in-country monitoring and surveillance, and contingency plans. Progress has been made in Burkina Faso to move to the next stage, with two PRAs conducted on the high-priority species *Aphis spiraecola* and *Fusarium oxysporum* f. sp. *cubense* tropical race 4.

In Bangladesh, a horizon scanning of potential invasive plant pests and diseases was organized for the first time, and the NPPO was introduced to the CABI horizon scanning tool.

In Pakistan, the last assessments from the horizon scanning activity were received and a publication is presently being written based on this.

PlantwisePlus has also supported an online series of webinars and trainings hosted by the Europe-Africa-Caribbean-Pacific Liaison Committee (COLEACP) on use of the Crop Pest Compendium (CPC), the horizon scanning tool and the PRA tool for NPPOs of ACP countries. The training included formal courses, demonstrations and exercises.

To ensure the CABI tools are more responsive to user needs, several improvements were undertaken, including the generation of a PRA report in French, and improvements to allow the PRA tool to conduct PRAs for a region or group of countries, rather than just single countries.

Training on the horizon scanning tool and the PRA tool have been conducted in many countries, both online and in face-to-face workshops. The tools and related methodologies developed in PlantwisePlus are now being increasingly used by countries to conduct PRAs, both pest-initiated and pathway-initiated, and to develop lists of priority species and strategies to combat them. These activities have been highly successful. There is a big demand from the NPPOs of countries that have received only basic training on the tools in online workshops to implement full PRAs and prioritizations of invasive species in face-to-face workshops. However, there is a limit to the number of such training workshops that can be organized per year. A solution would be to conduct regional horizon scanning and PRA training workshops, including on regional PRAs. This would also align with the African Continental Free Trade Area (AfCFTA) protocol.

Scaling out PRISE to more users

PRISE Bulletins were created and distributed in Kenya, Ghana, Zambia and Malawi. A partnership with Farm Radio Trust in Malawi ensures a more expansive reach. Pakistan has used the PRISE approach to run a theoretical test of accuracy of the FAW and *Tuta absoluta* models. Further fieldwork was conducted in Kenya to strengthen the data used to drive the beanfly models. The *Tuta absoluta* model is being prepared for publication, and the FAW model has been published by Crop Protection. Analysis of PRISE endline data was also undertaken during 2022.

A major challenge is to run PRISE alerts with dissemination partners without costs on either side. Although partners in all countries expressed a desire to do this, there are direct costs associated with SMS messages (for example) that need to be provided for by one or more partners, or donors. This has limited the reach of PRISE alerts, as a result of missing out on campaign involvement with Precision for Development in Kenya, Esoko in Ghana and the Zambian ministry of agricultures, Integrated Agriculture Management Information System (ZIAMIS)..

PRISE modelling and the maintained provision of the datacube (in partnership with Assimila) are key to PRISE expansion; these are non-negotiable components that provide and run the PRISE “engine” and need to be funded accordingly (i.e. model calibration in new geographies, new model development etc.). Ensuring the sustainability of a product/service beyond initial donor funding has proven very challenging.

Surveillance for pest threats

Following up on the horizon scanning, surveillance activities were conducted in Kenya for citrus canker, and in Ghana for BBTV and the Asian citrus psyllid. The samples from this surveillance are still being analysed, and will confirm the presence or absence of these threats.

Next steps

The work on insight reporting will continue to establish a scalable and sustainable mechanism for providing the reports, working with NPPOs to strengthen their capacity in risk-based approaches, including the use of insight reporting and other CABI tools and processes, and exploring additional tools that could be developed in this area for use by NPPOs, CABI or other stakeholders. A limited number of opportunities will be developed in more detail: for instance, the development of a pest risk register.

In relation to the social impact studies, two new pieces of work are planned for 2023: an assessment of farmer behaviour change from the campaign on cassava brown streak disease (CBSD) management in Zambia, and a social impact survey of the effects of *Listronotus setosipennis* on *Parthenium hysterophorus* in Pakistan. Field sites will need to be carefully considered, as no baseline was carried out before release. Therefore, the distinction between treatment and control sites will be paramount.

In 2023, priority will also be given to the continuation of the horizon scanning and PRA activities in Kenya, Zambia, Ghana, Burkina Faso, Bangladesh and Pakistan. However, training workshops and PRAs will be undertaken for regional blocks, to respond to the African Continental Free Trade Area protocol, e.g. for East African Community, Economic Community of West African States, and Southern African Development Community countries. At the same time, several functionalities of the PRA tool will be improved: in particular, the development of a French version, as requested by several African countries.

Other actions based on the results of the horizon scanning will be conducted in 2023, including other PRAs and monitoring for the presence of arthropods and pathogens suspected of already being present in Burkina Faso.

PRISE will seek to improve the efficiency and efficacy of pest control interventions at the field level (existing and new PRISE countries), to build the scope and scale of PRISE to encompass a wider portfolio of agricultural production risk outputs (product development, likely in Kenya initially), and to leverage the infrastructure, models and achievements already established (including developing routes to expand PRISE in new countries/developing new models where and as required).

Output 3.2 Co-ordinated pest preparedness, prevention and management through the use of the newly established decision support system

Executive summary

A stakeholder dialogue workshop on the invasive apple snail (IAS) *Pomacea canaliculata* was held in Kenya for the relevant stakeholders to share the latest information on the current status of the IAS in Kenya, including progress made towards its management, and to identify potential areas of collaboration. Two evidence notes (on cassava brown streak disease (CBSD) and *Limnobium laevigatum*) will be completed by year end, and published in 2023.

In Ghana, prevention and emergency preparedness plan for BBTV was developed to guide a response if the disease was to invade the country. The *Acerophagus papayae* releases in coastal Kenya proved that the parasitoid had established at all sites and up to 72% parasitism was observed. Two parasitoids were imported from Bolivia and Nicaragua to the CABI quarantine laboratory in Switzerland and Pakistan to assess their biology and specificity.

New field releases of *Telenomus remus* were conducted in Ghana, showing mixed results.

Research is also being conducted on the biological control of FAW using entomopathogenic nematodes in Switzerland and Rwanda. In Zambia, the effect of intercropping and planting dates on FAW densities and parasitism was assessed, whereas in Ghana, surveys were conducted to confirm and quantify the increase in natural parasitism since the arrival of FAW. In Pakistan, the production of the stem boring weevil was expanded to new production sites in other provinces, and over 7,000 weevils were released in several provinces. Establishment will be assessed in 2023, together with the importation of other biological control agents.

Awareness-raising campaigns were also conducted for three priority invasive species: IAS (recorded in Kenya for the first time in 2020); CBSD, which is devastating cassava yields in the northern parts of Zambia; and *Parthenium*, an invasive weed for which a tested and approved biological control agent is now being released in Pakistan.

The fieldwork for the FAO Global Action impact assessment has been completed in Kenya and India, and the qualitative and quantitative survey results will be brought together in a single report early next year.

More training to establish the cultures of biocontrol agents is still needed. Further, the success of biological control projects relies heavily on reliable external collaborators, in the region of exportation of natural enemies for classical biological control, and in the region of implementation for augmentative and conservation biological control. It is important to select reliable and efficient collaborators, and their costs should be budgeted. Involving communities in the research phase, and building on the traditional structure of communities, is critical for the long-term adoption, efficacy and sustainability of biocontrol.

Progress and lessons learned

Leveraging expertise for the management of the IAS in Kenya

CABI convened a one-day dialogue workshop on the IAS, for the relevant stakeholders to share the latest information on the current status of the IAS in Kenya, including progress made towards its management, and to identify potential areas of collaboration. The meeting brought together representatives from the multi-institutional team, including the Plant Protection & Food Safety Directorate (PP&FSD), the Kenya Agricultural and Livestock Research Organization (KALRO), KEPHIS, the Pest Control Products Board, and the National Irrigation Authority – Mwea Irrigation Agricultural Development (NIA-MIAD). It was agreed that CABI and KEPHIS would conduct delimiting surveys to ascertain the presence of IAS in Tana River schemes, as reported during the meeting (this is likely as Kirinyaga drains into Tana River and farmers come from Mwea). The need to put in place regulations for containment and quarantine measures and surveillance programmes whenever there is a new incursion was emphasized.

Evidence notes on priority pests and diseases

The evidence note on CBSD has been completed for Zambia, based on a literature review and fieldwork investigating current levels of farmer impact. Final numbers for the level of impact on cassava production are under review. The evidence note has been used as the basis of a communication campaign on CBSD in Zambia, focusing on prevention of the spread of the disease through farmer management approaches. Additionally, the evidence note for *Limnobium laevigatum* is currently being developed based on a literature review and climate matching models to predict regions in southern Africa at greatest risk, and will be completed by the end of the year. This evidence note will be used as the basis for creating awareness of this invasive species in southern Africa.

The timing of the publication of evidence notes needs to be considered when planning communication campaigns. It would be better to allow sufficient time to produce and publish a quality evidence note, before the campaigns begin, to ensure the information being disseminated is factual.

National prevention and management plans for priority pests

BBTV is a destructive viral disease of banana/plantain. Reports suggested that the disease was detected in Togo in 2018 but was eradicated in the same year. However, it was not clear if the disease may have found its way into Ghana. Like many other invasive species, BBTV invasion can remain undetected for a long period, posing a challenge to early detection and subsequent eradication or containment. Consequently, PPRSD, in collaboration with CABI, developed a prevention and emergency preparedness plan for BBTV in Ghana. Key stakeholders were invited to a one-day workshop to review and validate the draft document.

In Zambia, a national stakeholder workshop was held to develop a national response plan for CBSD, which was attended by CABI partners and stakeholders, including the Zambia Agricultural Research Institute, the International Institute for Tropical Agriculture, the Department of Agriculture, the Seed Control and Certification Institute, Musika, Zambia Breweries, media organizations, farmers, traditional leaders (Chief Kaputa), FAO, the Plant Quarantine and Phytosanitary Department, Dziwa Science Trust and the National Agricultural Information Service.

During the IAS dialogue workshop in Kenya, gaps, opportunities and recommendations were identified in order to inform a co-ordinated approach to addressing *P. canaliculata*, in the future. The broad areas of focus were policy, research and communication, management and co-ordination. At the policy level, there is a need to develop and align pest management strategies for IAS and other priority pests to the Migratory and Invasive Pests and Weeds Management Strategy.

Biological control of papaya mealybug

In 2022, more releases of *A. papayae* were made at 12 research sites in three coastal counties of Kenya: Mombasa, Kwale and Kilifi. Two releases were made at each site. Post-release surveys were conducted and showed that the parasitoid had become established at all sites, with parasitism rates of up to 53% after one release and up to 72% after the second release. Most research sites (=farms) visited after the second release showed very minimal incidence of papaya mealybug infestations (decreased pest populations and damage levels) after less than one full year since the biocontrol agent was introduced. This suggests that the project is a spectacular success. This data will have to be confirmed in 2023 by further surveys assessing the impact and the spread of the parasitoid; however, several African countries are now very interested in the release of the parasitoid within their borders.

Management of FAW

Classical biological control of FAW

In 2022, studies on FAW were carried out, mainly in Ghana, Zambia, Rwanda, Burkina Faso and Pakistan, with some fieldwork in FAW's native region in Latin America and quarantine studies in Switzerland. The work focused on the two parasitoid species collected in Bolivia and Nicaragua in 2019 and maintained in the CABI quarantine laboratory in Switzerland since then. The biology of the ichneumonid larval parasitoid *Eiphosoma laphygmae* and the braconid egg-larval parasitoid *Chelonus insularis* have been further studied and rearing techniques have been improved. *Eiphosoma* has now been tested on 14 non-target species in Switzerland and six in Pakistan. Only FAW was a suitable host, suggesting that it is highly specific and safe for introduction in Africa or Asia. A dossier for release is presently being prepared for Pakistan. The other species presently maintained in quarantine, *C. insularis*, is being tested although it is less specific and is able to attack and develop in three other *Spodoptera* species and two other Noctuidae.

Development of augmentative biological control of FAW

The potential of parasitoids in augmentative biological control against FAW is being assessed in Ghana, and methods to assess the quality of egg parasitoids on FAW in the laboratory have been developed in Switzerland. Work in Ghana focused mostly on the development of mass rearing techniques for the egg parasitoid *Telenomus remus* and field trials with this parasitoid. Improvements were made in the techniques for the mass rearing of *T. remus* in the laboratory, in collaboration with the PPRSD.

Use of entomopathogens for the control of FAW

Biological control of FAW using entomopathogenic nematodes is ongoing in Rwanda to determine the efficacy of the best formulations of nematodes against FAW in farmer fields. Field trials were implemented using the local nematode *Steinernema carpocapsae* RW14-GR3a-2. The results showed that correctly formulated nematodes in gels can indeed control FAW, as can pesticides. Field trials were also undertaken to assess whether the current dosage of 3,000 nematodes per maize plant can be reduced to reduce costs.

In Ghana, the effect of commonly used biopesticides on larval parasitoids of FAW was investigated. The study shows that some biopesticides are as effective as the most common insecticide used against FAW, and FAW in plots treated by the insecticide has a significantly lower parasitism rate as compared to plots treated with biopesticides. Thus, biopesticides should be preferred over chemical insecticides for FAW control.

In Zambia, one of the main natural enemies affecting FAW populations in the rainy season is the fungal pathogen *Metarhizium rileyi*, which can cause mortality rates of over 70%. Although this pathogen occurs in many countries affected by FAW, its effect in Zambia is particularly virulent. Therefore, the possibility of developing a biopesticide based on the local strain of the pathogen is being assessed. The work involves strain identification, bioassays and field efficacy tests. Bioassays with field larvae showed promising results in oil formulation; however, small larvae were killed from the oil instead of the fungus. The majority of the parasitoids developed successfully as adults, indicating that the fungus may not impact the developing parasitoids, increasing the environmental benefits of the fungus.

Conservation biological control of FAW

In Ghana, FAW parasitism by native parasitoids is increasing, whereas the general incidence of FAW is decreasing. Thus, a study has been initiated to assess the parasitism rate and the parasitoid complex of FAW populations. The study is comparing parasitism rates and the parasitoid complexes to confirm that parasitism by native parasitoids is increasing. The study is ongoing but preliminary results show an increase in parasitism rates, including egg parasitism by *Telenomus remus*.

In Zambia, several trials were undertaken to study the effect of agricultural practices on parasitism rates and FAW populations. In particular, the effect of intercropping was investigated, with promising results obtained in field trials conducted on-station. In on-farm studies, farmers established intercropping plots where FAW larvae and eggs were sampled and parasitism investigated. This data will allow us to provide reliable information on the effect of intercropping on FAW densities and parasitism, as well as recommendations regarding agricultural practices. Another study has investigated whether planting date has an effect on FAW densities and parasitism. The experiments all confirmed that maize planted early in the season is less attacked than maize planted later, with late planting having three times more

FAW larvae than early planting. In addition, the maize development stage was found to have an effect on parasitoids' occurrence, with some parasitoids occurring more on young plants and others more on older plants, independently of the date of planting.

Review of the invasiveness, biology, ecology, and management of FAW

A CABI-led study involving 57 scientists from 46 different institutions has provided a comprehensive and up-to-date review of FAW⁹. The review covers FAW's (i) taxonomy, biology, ecology, genomics, and microbiome; (ii) worldwide status and geographic spread; (iii) potential for geographic expansion and quarantine measures in place; and (iv) management, including monitoring, sampling, forecasting, biological control, biopesticides, agroecological strategies, chemical control, insecticide resistance, effects of insecticides on natural enemies, as well as conventional and transgenic resistant cultivars. The review concludes with recommendations for research to enhance the sustainable management of FAW in invaded regions.

Developing new management methods for newly invasive species such as FAW requires long, time-consuming and costly research activities, with uncertain outcomes, because methods that are effective in native areas or on other continents are not necessarily suitable in a newly invaded continent. The fact that there are few immediate solutions for new invasive species should be better considered in development programmes, and failures to find solutions, which is inherent in scientific research, should be better accepted.

Biological control of Parthenium weed

In Pakistan, the CABI facility at Rawalpindi has reached capacity production of over 3,000 *Listronotus setosipennis* beetles per month, reared from over 400 Parthenium plants monthly. These are being used for field releases at selected sites in the Punjab, Kashmir AJK, and Khyber Pakhtunkhwa (KPK) provinces and in Islamabad. Rearing facilities and expertise are presently being built in different provinces, in collaboration with local organizations to conduct more releases in regions of the country where Parthenium is most problematic. A total of 7410 *L. setosipennis* adults produced at the CABI facility were also released at 19 locations in KPK and Kashmir AJK provinces. After dissecting over 600 sunflower plants, it has also been established that the beetle does not feed on sunflowers planted alongside Parthenium plants.

CBSD campaigns – Zambia

The CBSD communication campaign in Zambia is two-pronged, in that it has been designed to support farmers who have low awareness of the disease, how to identify and manage it, as well as to raise awareness nationally of the issue and the need to act and mobilize resources so that farmers have access to disease-free planting materials. Recognizing that breeding is a long-term process, the CABI team began to investigate options for mass-producing clean planting material, learning from a small-scale scheme within the country, but also from experience in Uganda, a country which has implemented nationwide actions to support the management of CBSD

Activities aimed at raising awareness of the impact of CBSD and the need for clean planting material nationally have included a national stakeholder workshop which developed a national response plan. Media coverage of the event was considerable, with an audience of 662,000 according to media reporting statistics. To complement this work and to enhance the capability of public and private sector journalists and bloggers to report on the topic of CBSD, a training session was held for 39 journalists, aimed at enhancing the accuracy of reporting. Pre-recorded radio programmes were also broadcast on both the national station (ZNBC) and a selection of local radio stations in CBSD-affected areas. A radio backgrounder was also produced in collaboration with Farm Radio International and shared with 189 radio broadcasters across Zambia. A follow-up survey by Farm Radio International revealed that 12 radio stations had used the backgrounder in their reporting. A post-campaign review with farmers, the stations and the Department of Agricultural Extension Services revealed areas for improvement for follow-up activities, such as advertising of the programmes ahead of time to support listenership, the need to integrate live call-in shows with the pre-recorded elements to enable farmer questions to be answered, and a knowledge gap within the intermediary/extension service.

9 Kenis, Marc. (2023). Prospects for classical biological control of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in invaded areas using parasitoids from the Americas. *Journal of economic entomology*. 116. 10.1093/je/toad029.

Another key lesson from the 2022 campaign activities has been the need to diversify communication efforts to target national stakeholders in order to support the availability of solutions for farmers, such as clean planting material. This builds on learning captured from feedback on campaign work in 2021, which helped CABI and partners to design farmer-outreach activities that maximize the reach and impact and fill knowledge gaps among all relevant stakeholders.

IAS campaigns – Kenya

The IAS, first reported in Kenya in 2020, has become established in the Mwea Irrigation Scheme, where it is causing widespread damage to rice crops. Working with PP&FSD and NIA-MIAD, CABI conducted a two-day capacity building workshop on this pest, followed by one-day plant health rallies in Ahero and West Kano. Twelve participants – extension officers and irrigation officers drawn from Ahero, Bunyala, West Kano, Lower Kuja and Tana Delta Irrigation schemes – were trained on key aspects of IAS identification, prevention and management. This included training on how to plan and conduct plant health rallies.

Four rallies were conducted in Ahero and West Kano, respectively, which reached a total of 194 farmers. The team met to review their performance and suggest ways of improving future rallies. SciDev.Net published a policy-type news story on the impacts of the pest to raise awareness about the risks of IAS spread in the region. Three variants of IAS posters were also developed and printed: how to identify, manage and prevent the IAS; the IAS lifecycle; and an IAS photo guide. These were shared with the extension officers and irrigation officers drawn from Ahero, Bunyala, West Kano, Lower Kuja and Tana Delta Irrigation schemes.

The campaigns have built upon the data obtained from delimiting surveys conducted in Ahero, Bunyala, West Kano, Lower Kuja and Tana Delta Irrigation schemes. One key aspect that stood out is the modelling done, which shows that the IAS is projected to spread to other rice-growing schemes in the region, which has reinvigorated efforts by the government to raise funds to tackle its spread.

***Parthenium hysterophorus* campaign – Pakistan**

Parthenium has spread throughout much of Pakistan, causing problems in both rural and urban areas. The stem boring weevil *Listronotus steosipennis* was approved in 2021 for release as a biocontrol agent for the management of *Parthenium hysterophorus* in Pakistan. Therefore, a number of seminars, workshops, training of trainers and farmer field days were conducted to raise awareness among stakeholders on the management of parthenium with the stem boring weevil. The CABI team also participated in the Agriculture Expo held at Muzaffarabad AJK to demonstrate the rearing of stem boring weevil. A stakeholder workshop, followed by a training of trainers, was also conducted to sensitize and train key stakeholders on the stem boring weevil and the importance of research around the biocontrol of parthenium.

The biological control programme against parthenium weed is going as planned. The first agent, the beetle *L. setosipennis*, is presently being released and the programme is now being extended to several provinces. It is likely that, based on the experience of other continents, this beetle alone will not provide full control of the weed in Pakistan. Therefore, other agents should be considered for releases in the future.

Assessing the impacts of FAW action plans

In 2022, qualitative and quantitative fieldwork was completed in India and Kenya to assess the impact of FAO's Global Action on FAW. The qualitative data has been analysed, with preliminary findings indicating that in Kenya, testing and validation of FAW management practices was possible through strong farmer field school participation and engagement. In India, strong co-ordination of the response efforts led to an extensive and multi-pronged farmer awareness and advisory campaign. Key to the response in both countries was strong co-ordination and communication, and adequate financing. (The Global Action is a convening body led by FAO, that aims to bring together the work being done in a number of countries on FAW. The work that CABI, under PlantwisePlus has undertaken in Kenya is seen by FAO as part of the Global Action and therefore part of the assessment).

Next steps

The CBSD evidence note will be published as a working paper early in 2023, once final reviews of the document have been completed. A further evidence note will be developed, either on wheat rust or on BBTv. The *Limnobia* evidence note will be published as a journal paper in 2023.

Acerophagus papayae releases will start in Uganda but working in other countries (e.g. Zambia) should not be ruled out. An interesting case is Burkina Faso, where *A. papayae* was supposed to be established when it was released in West Africa some years ago. However, in contrast to countries of the Guinean coast, problems with papaya mealybug remain in Burkina Faso. A study in 2023 will assess the presence and effect of *Acerophagus papayae* and other parasitoids in Burkina Faso and, potentially, release of the parasitoid if absent.

Releases of the beetle *L. setosipennis* against *Parthenium* will continue in 2023. A protocol for post-release monitoring to assess the establishment of the beetle and its ability to overwinter in different climates has been developed, and post-release surveys will be conducted in 2023.

A dossier will be prepared and submitted for the release of *E. laphygmae* in Pakistan and, if possible, releases will be started. New populations of *E. laphygmae* will be made in Latin America to boost the current colony. *Campoletis* sp. and other parasitoid species will continue to be collected from Latin America for quarantine rearing and specificity testing in Switzerland and Pakistan. A decision will also be made regarding the prospects for and risks of releasing *C. insularis* in Africa and/or Asia.

Follow-up studies will be undertaken on the implementation of the entomopathogenic nematode work on FAW in Rwanda, and the efforts to develop a *Metarhizium rileyi* formulation for FAW in Zambia – strain identification, bioassays field efficacy testing – will be accelerated.

New work on the tomato leaf miner will be initiated in 2023, with a focus on the development of production methods for the predatory bug *Nesidiocoris tenuis*.

In Zambia, efforts in 2023 will continue to support the availability of clean CBSD planting materials, which is likely to focus on the development of a training curriculum for multipliers of materials, in order that they meet the necessary quality requirements, among other activities. As clean planting materials become available there will be a shift in the messaging to farmers, to supporting them in finding and accessing the planting materials required. Based on further data about the spread of CBSD in the country, it may be possible to support a categorized campaign, with messaging which is targeted to the status of each region. For example, where CBSD has yet to spread, the messaging would focus on restricting the introduction of planting materials from outside of the zone and implementing phytosanitary processes.

CABI will continue to support PP&FSD in regard to long-term and sustainable management of the IAS in Kenya. More posters will be printed to further help create awareness in each of the rice irrigation growing schemes in Kenya. Copies would also be printed for use by PP&FSD and NIA-MIAD.

In Pakistan, social and behaviour change interventions around *Parthenium* and FAW will be undertaken, through different communication channels.

The quantitative data analysis from the FAO Global Action work will be completed early in 2023, as will the reporting to bring together both the qualitative and quantitative work, providing findings on whether the FAO Global Action had an impact on the ground and whether the convening efforts by FAO made a difference in regard to any observed impact. In addition, an assessment will be carried out of the progress in implementing an FAW action plan and invasive species system in Bangladesh.

PlantwisePlus Specific Objective 4: To develop capacity and systems for local production and distribution of low-risk plant protection products

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Output 4.1: Enhanced capacity among agro-input dealers following voluntary standard on IPM and pesticide risk reduction

Executive summary

The overall aim of Output 4.1 is to help agro-input dealers sell more low-risk plant protection products (PPPs) and potentially develop voluntary certification schemes for agro-input dealers. Drawing on in-country baseline knowledge, specific constraints and needs were identified and potential capacity building of agro-input dealers on low-risk PPPs was explored.

In 2022, a full analysis of the legal requirements for being an agro-input dealer in 17 countries was completed and a synthesis report comparing differences was prepared. For the agro-dealers certification scheme it was decided that the training needed to be tailored to the requirements for each country. Hence, the needs study carried out in 2021 in Uganda was analysed and two peer-reviewed papers were submitted for publication. The highlight of the report was that only 16% of the 557 agro-input dealers interviewed were selling biopesticides. A further larger-scale (538 agro-input dealers) needs assessment was carried out in Nepal in October/November.

The Ugandan Ministry of Agriculture did not want an independent voluntary certification scheme on low-risk PPPs. At a follow-up meeting with the Ministry of Agriculture and Makerere University it was decided that CABI would prepare training material on the findings of the needs assessment related to safer PPPs, and that the new training material would be incorporated into the mandatory registration system.

Further “mini” assessments were conducted in 12 different countries. Three of these country assessments – China, Costa Rica and Zambia – were prepared as CABI working papers, to highlight some differences between different continents, i.e. Asia, South American and Africa.

In China, a proposal was developed, with Leshan Prefecture Plant Protection Station as the lead institute, to assess the potential of setting up a voluntary certification scheme for agro-input dealers based on the Plantwise Classic rating scheme for “Model Agro-shop”.

Progress and lessons learned

A baseline study was carried out in June/July 2021 to review the current regulatory frameworks governing the operating environments for agro-input dealers in 17 different countries, to determine the current requirements for registration, training and/or certification as a regulatory obligation, and any existing gaps or needs. In 2022, the studies were prepared as 17 country reports and highlighted the vast variation in requirements for becoming registered agro-input dealers.

To synthesize the 17 different reports, it was decided that a formal cross-country analysis document should be developed. WRENmedia, a consultancy firm specializing in agricultural development communication, worked with CABI to produce a synthesis report on the variation in the requirements for registering as an agro-input dealer. In early 2023, the resulting report will be further developed into a CABI working paper or a peer-reviewed article.

To fully assess the requirements for any voluntary agro-dealers certification scheme on the use of low-risk PPPs, it was decided that two large-scale (Uganda and Nepal) and 12 mini needs assessments needed to be carried out. The Uganda assessment and the 12 mini assessments were carried out in November/December 2021 and analysed in 2022. The Nepal assessment was carried out in October/November 2022 and will be assessed in Q2, 2023.

The Uganda needs assessment results showed that a very high number of agro-input shops visited were selling at least one high-risk pesticide product, but only 16% were selling biopesticides, due to unawareness, lack of demand from farmers and lack of access. Results from a discrete choice experiment revealed that the concept of a voluntary sustainability certification scheme is greatly valued by agro-dealers, particularly for its potential to provide training opportunities and to ensure safety in regard to human health and the environment. The survey results suggest that agro-dealers have a positive attitude towards a voluntary certification scheme that restricts the sale of high-risk products, especially if it stimulates additional income-generating opportunities, such as the provision of pest diagnostic and IPM-based advisory services. In conclusion, agro-dealers are conscious of pesticide risks to human and environmental health and are keen to participate in a certification scheme promoting safer PPPs. The survey results indicate that many of the agro-input dealers interviewed were willing to pay for a voluntary certification scheme. However, there is significant doubt over these results and future surveys will rephrase the questions on this subject so that the agro-input dealers fully understand that they would be expected to pay and the scheme would not be subsidized.

Once the final report of the needs assessment was completed it was submitted to the Commissioner for MAAIF. A meeting was subsequently organized, via Zoom, to discuss the findings of the report. During this meeting the Commissioner clearly stated that the ministry would not support the development of a voluntary certification system and would rather collaborate on the strengthening of the existing mandatory scheme. It was proposed by MAAIF to hold an in-country workshop to disseminate the findings of the study.



Figure 3: Uganda workshop on the agro-dealers needs assessment findings, held with MAAIF, the Uganda National Agro-Input Dealers Association, Makerere University and representatives of industry and NGOs

A follow-up workshop took place in Kampala, Uganda, on 10–11 October 2022 (Figure 3). The aim was to share and validate the findings of the agro-input dealers needs assessment study and to explore potential areas for collaborative enhancement of existing agro-input dealer training, with a focus on improved capacity in aspects of IPM, including low-risk PPPs. It was agreed, in principle, for CABI to develop a format and content for the delivery of training material on low-risk PPPs, and in particular biopesticides. A planning/development workshop will be held early in 2023 to finalize details.

A second needs assessment for agro-input dealers was developed for Nepal. The tools developed for Uganda were used in this assessment, after some modification. This study was also applied a discrete choice experiment to elicit and analyse agro-input dealers' preferences in regard to different attributes of a voluntary certification scheme. In total, 538 individual agro-input dealers across seven provinces were interviewed in October/November 2022. The data will be analysed in Q2 of 2023.

In addition to the two large-scale needs assessments, 12 mini assessments were carried out in Bangladesh, China, Costa Rica, Ghana, India, Jamaica, Malawi, Nepal, Pakistan, Peru, Sri Lanka, Uganda and Zambia. Analysis of the results indicated a general interest in the development of a voluntary certification scheme and a willingness to pay. However, feedback from key stakeholders,

particularly government representatives, was more cautious in interpretation. Most indicated that, although there would be a genuine interest in participation in training, there was a reality gap between the willingness to pay expressed and the actual willingness to pay. It was suggested that the expectation would be that a donor agency would provide funds and that the agro-input dealers were unlikely to be interested in actually investing their own funds. It was suggested that the sustainability of any voluntary scheme would be unlikely based on subscriptions from agro-input dealers.

As some of the mini reports were of a very high standard it was decided to release three reports (those on China, Costa Rica and Zambia) as CABI working papers. It is expected that these will be finalized by the end of Q2 2023.

In China, a provincial-level local standard proposal (in Chinese) was developed based on the agro-shop rating system piloted in Qianwei county since 2018. The proposal was submitted to the Department of Agriculture and Rural Affairs of Sichuan province in October 2022. The proposed standard was entitled “Sichuan Province Pesticide Management Green Control Promotion Model Shop Standard Requirements and Evaluation Code”. The proposal described the need for and feasibility of the standard, and explained the idea, the working plan, and the supporting strategy. Leshan Prefecture Plant Protection Station is the lead applicant organization, and CABI China is one of the partners in the proposal.

Overall, these extensive interactions with agro-input dealers and related associations across several countries provide the insight that it may be most effective to implement new training in countries where no training is currently offered to agro-input dealers.

Next steps

- In early 2023 the agro-dealers regulatory report will be further developed into a CABI working paper or a peer-reviewed article.
- The Nepal agro-dealers needs assessment will be completed, and a report written.
- A peer-reviewed paper on the Nepal agro-dealers needs assessment will be written and submitted to a journal.
- Three CABI working papers, from China, Costa Rica and Zambia, will be completed on the ‘mini’ needs assessments of agro-input dealers’ desire for a voluntary certification scheme on low-risk PPPs.
- A workshop will be held to clearly identify content for, and the implementation plan for, developing training materials in Uganda.
- Training material for Uganda will be developed, in collaboration with the Government of Uganda and Makerere University.
- An in-country trial training course for agro-input dealers in Uganda and/or Nepal will be delivered and facilitate.
- A study on post-training uptake of low-risk PPPs will be conducted.
- An in-country workshop will be held on developing a voluntary certification scheme and possible business models.
- A gender uptake study will be conducted in Nepal, looking at how agro-input dealers can reach women farmers.

Output 4.2: Regulators engaged towards low-risk plant protection product registration and use, with a focus on specific crops

Executive summary

The overall aim of Output 4.2 is to work with government regulators to make it easier to register, and hence increase the availability of, low-risk PPPs. In 2022, activities have been carried out in Sri Lanka, Pakistan, Ghana and Kenya, with varying success.

In Pakistan, it was disappointing that the new regulations for registering low-risk PPPs have still not been ratified, despite continued effort by the CABI Pakistan team. Instead of the planned “biopesticide roadshow” and putting AflaPak through the new regulation system, a CABI working paper was prepared on the processes carried out in developing new low-risk PPPs registration. This paper will be published in 2023 and is being used to guide the work being carried out in Sri Lanka.

Due to the ban on chemical inputs in Sri Lankan agriculture in 2021, it was decided that Sri Lanka would be a good country to offer assistance to in regard to helping to register more low-risk PPPs. Unfortunately, due to political unrest, there was a delay to this activity. A preliminary meeting was held in July 2022 with five members of the Sri Lankan Department of Agriculture, to assess their interest in working with CABI. After internal discussions, the Department of Agriculture accepted assistance from CABI. A meeting in early 2023 will finalize a workplan for the year.

In 2021, three draft reports on safer alternatives to imidacloprid, mancozeb and metalaxyl had been prepared. This year, the draft report for Pakistan was shared with the relevant stakeholders; they had no further comments on it. However, Pakistan was experiencing political upheaval at the time. In Kenya, a workshop was held involving the relevant stakeholders. The risks associated with pesticides is currently a hot topic, and pesticide withdrawal is a particularly sensitive subject, which made it clear that any further work in this area should be done through a stepwise approach, first with the engagement of the public sector and their leadership at all stages. A similar workshop, learning from the lessons from the workshop in Kenya, will be held in Ghana in 2023, co-chaired by CABI and the Environmental Protection Agency of Ghana.

Progress and lessons learned

Unfortunately, due to delays in receiving a decision from the Pakistani Government there was no progress in implementing the new low-risk products registration. There is still no indication of when the new regulations will be reviewed. The “Biopesticides Roadshow”, which was planned to inform stakeholders of low-risk PPPs and the new regulations, was not able to take place. This work will be carried forward to 2023, subject to approval of the new regulations by the government.

To progress work, while waiting for the Pakistani Government to ratify the new regulations, it was decided to prepare a CABI working paper on the process undertaken to implement new biopesticide regulations within Pakistan, in order to guide the process in other countries. Working with WRENmedia, a CABI working paper has been prepared and will be sent out for review in early 2023.

To expand the work on registration analysis, it was decided to draw on the experience in Pakistan, in work with other countries that have shown an interest in increasing the use of low-toxicity PPPs. In April 2021, the Sri Lankan Government imposed a ban on the import and use of agricultural chemical pesticides and fertilizers, with the aim of producing organic food. This resulted in a 54% reduction in crop yield. CABI contacted the Sri Lankan Department of Agriculture, via Dr Hemachandra (a CABI consultant), to offer assistance in relation to getting more low-risk PPPs registered and available for use in country.

This work was delayed due to the political unrest in Sri Lanka in April/May 2022. When things had become more stable, an initial meeting was held on the 20 July, involving collaborators from the Sri Lankan Department of Agriculture and Peradeniya University, to explore the way forward in light of the political unrest. It was decided that CABI’s assistance would be valuable to help with increasing the registration of biopesticides, but that there would need to be a delay to the start of the work until the political situation improved. A follow-up meeting was held in December and a plan was formulated to start formal discussions with the Ministry of Agriculture in early 2023.

In 2021, three draft reports were prepared, for Ghana, Kenya and Pakistan, on the potential impact of the withdrawal of high-risk PPPs (imidacloprid, mancozeb and metalaxyl) from the market and the identification of available alternative pesticides and crop production practices. Once the reports had been compiled it was evident that there was a need to engage with relevant national stakeholders on the development and prioritization of a shared list of high-risk PPPs.

In 2022, the aim was to further develop the concept for insight reports and to agree on the approach for delivery. One major achievement in 2022 was the co-convening of a roundtable workshop by CABI and Kenya's Pest Control Products Board, with the participation of many of the major players in Kenya with an interest in pesticide regulation and the identification of lower-risk PPPs to meet market requirements, including organizations from the public and private sectors, and farmer organizations.

In Kenya, risks associated with pesticides is currently a hot topic, and pesticide withdrawal is a particularly sensitive subject. One key lesson learned is that addressing high-risk PPPs and promoting the uptake of lower-risk alternatives needs to be done through a stepwise approach, starting with engagement with the public sector and their leadership at all stages. This is due to the sensitive nature of the subject of pesticide residues and possible removal from the market.

A similar roundtable workshop is planned in Ghana in Q1, 2023. This activity is seen as the beginning of a process that needs to be sustained with the regulators – EPA (mainly) and PPRSD (to some extent). In view of this, CABI will co-organize the roundtable with EPA to establish the framework (owned by the EPA) for constantly scanning the horizon to see what active ingredients are to be phased out and to clear the way for substitutes.

The Pakistani report was shared with the relevant stakeholders. They had no additional comments and no further action was taken.

Next steps

- Publication of the CABI working paper on the process of adapting/adding biopesticide regulations to national pesticide registration.
- Running an in-country “Biopesticides Roadshow” in Pakistan, subject to government ratification of the new biopesticide registration procedure.
- Putting Aflatox through the new biopesticide registration procedure, once it is ratified by the Pakistani Government.
- Carrying out a virtual workshop to decide the plan of action for assisting Sri Lanka with getting more low-risk PPPs registered.
- Running an in-country “Biopesticides Roadshow” in Sri Lanka, dependent on there being sufficient political stability.
- Submitting the Pakistan paper on alternatives to Highly Hazardous Pesticides (HHP) as a CABI working paper.
- Holding a workshop in Ghana on the “alternatives” report.
- Preparing alternatives to HHPs identified in agreement with Sri Lankan Government.
- Holding a follow-up meeting/workshop in Kenya on alternatives to chemical pesticides.

Output 4.3: New agricultural businesses for low-risk plant protection products

Executive summary

The overall aim of Output 4.3 is to identify low-risk, IPM-compatible solutions and to set up low-technology mass production/rearing facilities. In the longer term (beyond the proof-of-concept phase), successful establishments will be considered in regard to turning them into community-based enterprises, employing youth and women, primarily.

Trichogramma species are parasitic wasps that are good at controlling many different pests. In 2022, *Trichogramma* species have been considered as suitable biocontrol agents for use in Bangladesh and Pakistan. In Bangladesh, a scoping visit in September concluded that *Trichogramma* would be suitable as a biocontrol agent against the brinjal shoot and fruit borer (*Leucinodes orbonalis*) and/or Cotton leaf worm (*Spodoptera litura*). Both are pests of brinjal (aubergine). CABI will partner with Bangladesh Agricultural Research Institute (BARI) to potentially host the new *Trichogramma* mass rearing facility at the Spice Research Centre in Bogura.

In Pakistan, a new *Trichogramma* rearing facility has been established in Khyber Pakhtunkhwa. Another facility is planned for South Punjab, once a memorandum of understanding (MoU) is signed by the Government of Punjab. A capacity building training course on how to mass rear *Trichogramma* using the new facilities was held in December for 10 participants.

The gender study on potential challenges and barriers to the adoption of the *Trichogramma* technology in Pakistan that was carried out at the end of 2021 was analysed and a paper was submitted to a peer review journal in 2022. A further gender study was carried out in Nepal in December on “gender dynamics and social norms determine technology access and use”, looking at how agro-input dealers can better reach women farmers.

Following on from the success in Specific Objective 3: To strengthen systems for detection and response to pest outbreaks, of finding a suitable parasitic wasp to control the papaya mealybug on papayae in Kenya, production of *Acerophagus papayae* was moved to Specific Objective 4: “To develop capacity and systems for local production and distribution of low-risk PPPs”. In March 2022, Abdul Rehman (CABI Pakistan) ran a training course on the mass rearing of *A. papayae* in Kenya. As a result of the training, by the end of the year production increased from 500 adults in January to over 100,000 mummies a month since July. The mummies were released on mass from July to December, covering eight districts on the Kenyan coast, with very promising results. During the release programme, farmers were trained on how to get the most out of the parasitic wasps.

In Zambia, a potential fungal-based biocontrol agent, *Metarhizium rileyi*, was found to be naturally killing FAW. This fungus was isolated and taken to the UK for further studies. It was first placed through the CABI “commercial” quality mass production system to determine its potential as a commercial product. The mass production was successful and hence further molecular studies were carried out to be able to distinguish it from other *M. rileyi* isolates. The molecular studies show promise and will be further explored in 2022.

In November 2022, mass-produced spores were taken to Zambia to determine their pathogenicity against FAW. The results showed that the spores were pathogenic although the carrying oil will need to be addressed as it was toxic to the smaller FAW larvae.

Progress and lessons learned

In 2022, a vast range of activities have been carried out, in five countries: Bangladesh, Kenya, Nepal, Pakistan and Zambia. The paragraphs below describe the activities by country.

Bangladesh

Bangladesh has been identified as a PlantwisePlus focus country and it was proposed to assess the potential for developing a low-technology pilot mass production facility in Bangladesh. Through discussions with CABI staff in South Asia and local counterparts at BARI, Gazipur, it was identified that a pilot facility to produce *Trichogramma* to manage an insect pest (brinjal shoot and fruit borer (*Leucinodes*

orbonalis) and/or Cotton leaf worm (*Spodoptera litura*)) of brinjal (aubergine), a major crop in Bangladesh, would be of interest.

A scoping mission to Bangladesh was carried out in September 2022 to review the current status of production of biopesticides, in particular *Trichogramma* in Bangladesh. The aim was also to assess the level of need for and interest in developing a low-technology, pilot mass production facility in an agricultural area of Bangladesh. The BARI centre in Gazipur was visited and the Entomology team provided a tour of their current small-scale production facility. Detailed discussions were held on the possible target pests and potential locations for the pilot facility.

A number of possible facilities that could host the pilot *Trichogramma* facility were visited and the Spice Research Centre in Bogura was identified as a promising location. The local team were enthusiastic and supportive and it is located within an agricultural zone. Although the targeting of the vegetable production is outside their mandate, as part of BARI they are able to host the pilot facility. The rooms available were in good condition and provide ample space to install a production facility.

The limiting factor was that currently there is no MoU in place with BARI or at the government level. Although there is definite interest from the Director of BARI and staff in developing a mass production facility, no progress can be made until the MoU is in place.

Kenya

Papaya mealybug, a pest of papaya trees, invaded Kenya in 2016 and has been reported to causes annual losses of 57% yield and £2,224/ha. In December 2020 *A. papayae* (a parasitic wasp) was imported from Ghana (where it was shown to be successful at controlling papaya mealybug) to Kenya under a research-only licence. After successful efficacy trials in quarantine (under Specific Objective 3) it was approved for release in 2021. The first release was in December 2021 in the coastal region of Kenya. The initial field released looked promising so the scaling up of *A. papayae* was transferred to Specific Objective 4.

In order to achieve mass rearing of *A. papayae*, Abdul Rehman, from the CABI Pakistan centre, carried out a three-day training course for 10 participants (six CABI and four KALRO staff), at the Muguga site. The course covered the theory and practical aspects of mass rearing *A. papayae* at scale. There was also two days in the field looking at papaya mealybug infections and farms where *A. papayae* had previously been released, to see the evidence of control.

Following the successful training course, the mass rearing facility at Muguga, Kenya, has increased production from 500 adults in January to over 100,000 mummies a month since July, after a three-month scale-up. In total, 396,000 mummies have been released on 6,588 trees on 122 farms, with a total acreage of 88 acres. The appearance of papaya mealybug has been greatly reduced on farms where the *A. Papaya* has been released.

Nepal

Gender dynamics and social norms determine technology access and use. Even though no role is necessarily exclusively performed by just women or men, the traditional division of labour tends to assign specific responsibilities along value chains to women and others to men. As a consequence, women often have unequal access to key agricultural inputs, such as land, labour, knowledge, fertilizers, and improved seeds. A study is being developed to address this issue, with a focus on the link between agri-input dealers and women farmers, and how this can improve women farmers' access to technology and knowledge.

The study will be carried out in Nepal in December 2022, in four to six districts which will be identified during the enumerator training workshop from the following suggested districts, based on high pesticide use in vegetable production: Kathmandu, Lalitpur, Bhaktapur, Nuwakot, Kavre, Hetauda, Morang, Jhapa, Janakpur, Sarlai, Siraha, Bara, Chitwan, Dhading, Kaski, Syangja, Lamjung, Tanahu, Rupandehi, Kapilvastu, Nawalparasi, Dang, Banke, Bardiya, Kailali, and Surkhet.

Pakistan

A gender assessment of the potential challenges and barriers to adoption of the *Trichogramma* technology in Pakistan was carried out in 2021 (see report 4.3.1, 2021). The analysis was carried out during 2022, with a final draft manuscript being submitted for peer review in November 2022.

This study aimed to look at the gender-related barriers to uptake of *Trichogramma* by farmers in Punjab, Sindh and Khyber Pakhtunkhwa provinces of Pakistan. KIIs were conducted with researchers and agriculture extension staff involved in the dissemination of the technology. In-depth interviews and focus group discussions were carried out with women and men farmers using *Trichogramma*, and non-user farmers. The results showed that targeting women directly in communication about the biocontrol method helped to improve uptake by farming households. The reduced health risk of the biocontrol method was important for women farmers, while men farmers were more concerned about the effectiveness of the biocontrol method as compared with pesticides. Using *Trichogramma* helped to reduce male time and labour spent on pest management and improved yield and income. However, it increased the demand on women's time and labour, while their decision-making role in regard to the income from tomato production remained low. Lack of information, training and a reliable supply were the main reasons for not using *Trichogramma* reported by non-user farmers. The findings are expected to inform the dissemination and implementation of the piloting and scale-out of the technology to be more gender-responsive and to benefit men and women farmers.

At the end of 2021 it was agreed that the focus of the development of the low-technology mass production facility for *Trichogramma* would be South Punjab, Pakistan. The CABI team initiated discussions with local institutes and ministry officials to begin to identify partners and roles and responsibilities within the development of the pilot facility, as part of Activity 4.3.2. Initial discussions were held with the Director General Agriculture (Extension and Agricultural research) Punjab Province and interest was expressed in hosting a *Trichogramma* Rearing Facility (TRF) in South Punjab. Through a number of missions to Pakistan and local CABI staff visits to key stakeholders, progress towards the establishment of a facility in South Punjab has been made. It was agreed that the location of the TRF in South Punjab would be the Biocontrol Facility at the Deputy Director Agri. Extension Office, Muzaffargarh, South Punjab. Detailed discussions were held with the staff at the facility and with an external technical adviser to plan the layout of the facility and to identify the renovations required. In addition, detailed discussions and plans were made for the construction of equipment for the facility based on designs developed for the TRFs in the CABI-EU Mekong project and the recently developed TRF facility at MARDA in Malaysia.

Although detailed renovation requirements, lists of equipment to be purchased and lists of equipment to be constructed have been prepared, progress was stalled throughout 2022 due to the ongoing requirement for an MoU to be signed between CABI and the Government of Punjab Province. An updated MoU was assessed near the end of 2022 and approval was finally given. It is now anticipated that the work at the Punjab facility can proceed early in 2023.

In parallel, discussions were held with the provincial authorities in KPK province, in Peshawar in May and August 2022, during CABI external missions to Pakistan, and also continuously during the year by local CABI Pakistan staff. Initially, there was interest in developing a TRF in KPK as part of an ongoing KPK-CABI project; however, a decision was made to support this activity with PlantwisePlus funding. During the August mission the Secretary of Agriculture, Dr Muhammed Israr, indicated that there were buildings available to host a TRF. A brief inspection was conducted of a potential site at Jamra Seed Production Farm, Takht Bahi, Mardan, KPK. Two buildings were available which could be adapted to house either the *Trichogramma* or the *Corcyra* production process. It was agreed, in principle, that the TRF could be installed at this site, following a security assessment.

The facility at KPK has now been renovated and the equipment has been installed. A CABI expert in the rearing of *Trichogramma* ran a training course for 10 personnel from across the two proposed sites and some CABI staff, to facilitate in-country capacity building. This will lead the way for mass rearing and release of *Trichogramma* in 2023.

Zambia

Metarhizium rileyi is a naturally occurring fungus that was found infecting FAW in Zambia. The isolate was molecularly identified by CABI in 2021. The aim of this study was to further characterize and obtain markers for the *Metarhizium rileyi* isolate. This will be useful for several reasons, including: 1) to give

some form of protection to the producers should a third party seek to sell on the *M. rileyi* strain but claim it as their own novel strain; 2) to give regulators/authorities confidence that the *M. rileyi* strain can be tracked; 3) to enable ongoing and batch-to-batch 'production quality control' for producers. The results are promising, with markers detected that appear to differentiate this *M. rileyi* strain from others that are held in the CABI culture collection. Further work in 2023 will confirm these initial findings.

At the biopesticide facilities in CABI UK, infected FAW were received from the CABI Zambia team. The fungus was removed from the infected insects and pure cultures were obtained. Once this process was completed a mass production run, using the standard CABI mass production protocol, was carried out. The *M. rileyi* was a lot slower growing than previous *Metarhizium* species we have worked on. However, it did produce spores and has the potential to produce spores artificially.

A sample of the first batch of spores was sent to Zambia in March, to test if the spores were still pathogenic to the FAW larvae. The CABI Zambia team then carried out a bioassay exposing the FAW larvae to a high level of *Metarhizium* spores. The inoculated insects all died by day seven (Figure 4).

In November 2022, CABI experts visited Zambia to carry out dose response bioassays on the FAW using the second batch of mass-produced fungi. A bioassay was set up with the following concentrations: 1×10^9 , 1×10^8 and 1×10^7 spores/ml. The spores were suspended in Sunfoil, a locally available sunflower oil. The FAW larvae used in the bioassay were collected from the field. It was decided that a further bioassay would be set up with additional FAW collected from the field. In total, 134 FAW were inoculated with three different concentrations of *M. rileyi*, with 41 controls inoculated with Sunfoil oil only.

A large proportion of the FAW had been infected with parasitoids (although that was not obvious at the time of inoculation). Furthermore, the smaller FAW larvae were killed by the Sunfoil alone. This means that an alternative to Sunfoil will be required for formulation of the spores. It is likely that an emulsion-based formulation will be best for this situation.

In 2020, an Excel sheet listing low-technology mass production systems was compiled. This year that data has been added to a dashboard creation so that the information is in an easy-to-search system as an internal document for CABI staff.

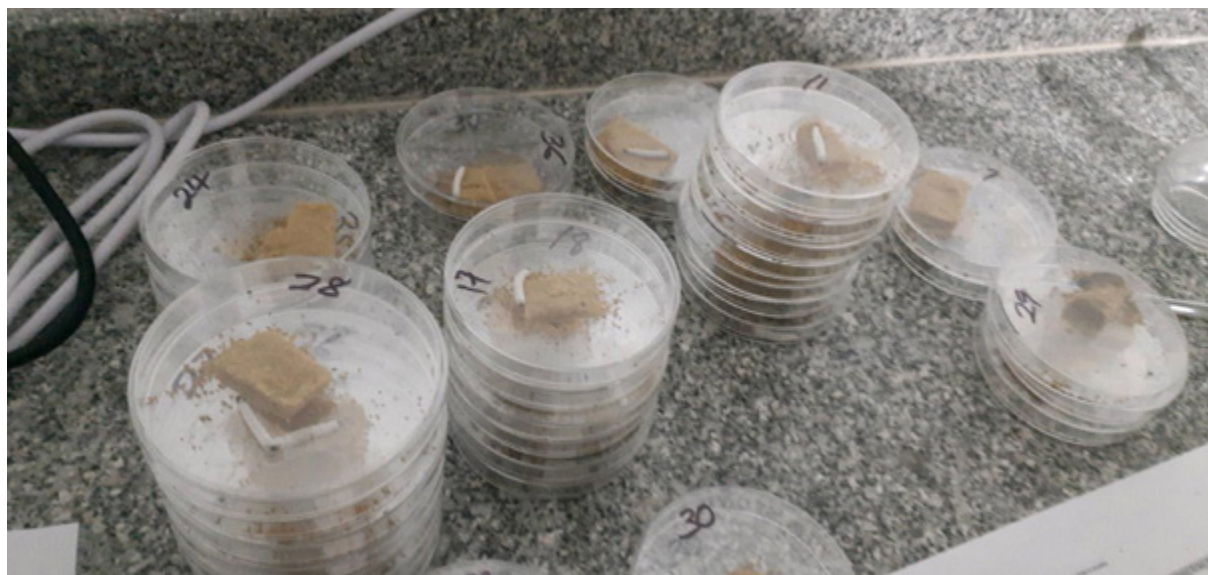


Figure 4: Dead FAW larvae showing the white fungal “coating”. This “coating” turns green when the fungus sporulates

Next steps

- Obtaining sign-off on an MoU with South Punjab and setting up a mass rearing facility in Muzaffargarh.
- Carrying out follow-up training in Pakistan on rearing *Trichogramma*.
- Preparing and signing off an MoU with the Bangladesh Government and with BARI.
- Holding an initial workshop to develop a roadmap for the development of the mass production facility in Bogura, Bangladesh.
- Preparing rooms and equipment to install a functioning *Trichogramma* facility in Bangladesh.
- Delivering a training workshop and technical backstopping for the Bangladesh facility staff.
- Analysing the gender analysis from Nepal and preparing a working paper or peer-reviewed publication.
- Continuing with the mass release of *A. papayae* in Kenya.
- Carrying out a study on the successfulness of the Natural Enemies Field Reservoir (NEFR) technology in Kenya.
- Carrying out a gender update study on the use of *Metarhizium rileyi* to control the FAW in Zambia.
- Continuing with molecular studies on *Metarhizium rileyi*.
- Carrying out a study on “understanding farmers’ ‘keenness’ to use biopesticides”.
- Finalizing dashboard creation for the low-technology mass production database.

PlantwisePlus enables countries to confidently face the challenges of plant health threats in a changing climate by empowering smallholder farmers to increase income, food security and food safety by producing more and higher quality food.

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