From China to Rwanda: successful transfer of biocontrol for soil insect pests

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Summary

Whilst the majority (~80%) of Rwanda's population depend on agriculture, yields are often adversely affected by a range of factors – including soil insect pests – resulting in significant impacts on food security, incomes and gross domestic product (GDP). However, a biocontrol transfer project, that has made environmentally-friendly crop protection technology originating from China available to farmers in Rwanda, is stabilizing vegetable crop productivity. As a result of a successful triangular partnership between China, Europe and East Africa, the project led to the selection of five local beneficial nematodes for soil insect pest biocontrol, their mass production and field application in Rwanda. Numerous in-country capacity building activities and a study tour to China facilitated the transfer and adaption of the technology, and laid the foundation for scaling it out to farmers across Rwanda and, potentially, elsewhere in East Africa.

Key highlights

- A household and market survey assessed Rwandan smallholder farmers' socio-economic status and soil insect pest control needs.
- More than 40 different soil insect species identified – with various white grubs, cutworms and bean-flies selected as key targets for pest control in vegetable or tuber crops.
- Nine local beneficial insect-killing nematodes and their symbiotic bacteria isolated from Rwandan soils and five screened for biocontrol efficacy against target soil insects; their application demonstrated in experimental and farmers' fields.
- The first beneficial nematode mass production factory set up in Rwanda; Chinese biological crop protection technology successfully transferred to Rwanda and adapted for local conditions.

- Guidelines for effective incorporation of beneficial nematodes in integrated vegetable production developed and disseminated to local extension staff, technicians and farmers.
- A dissemination strategy developed for future scale-out and uptake.

Context

In Rwanda, about 80% of the population depend on agriculture for their livelihoods and the sector contributes one-third of GDP. Agricultural products provide essential household food and income, but yields remain irregular due to a range of factors including soil insect pests. These pests not only damage vegetable and tuber crops – resulting in total yield losses in some regions – but the effects of infestation filter through the entire value chain with significant impact on smallholder households. Poor yields result in reduced food for household consumption and, as demand for agricultural products exceeds supply, increased prices make food more expensive, particularly for disadvantaged groups. In addition, food crops damaged by soil insect pests are prone to secondary infections, reducing shelf-life. However, controlling soil insect pests poses a number of challenges. Firstly, soil insect pests occur below ground, making detection and control difficult. Secondly, most farmers (76%) lack appropriate knowledge and skills on soil insect pest control. Thirdly, soil pesticides are either unavailable or costly, are usually highly toxic to humans, may have serious other non-target effects, or are banned from use nationally or internationally.

With one of the highest population densities in Africa and an influx of refugees from neighbouring countries, land and resources in Rwanda are stretched. Consequently, any threat to agricultural production has serious and far-reaching effects. Offering Rwandan farmers better options for soil insect pest control would improve household food security, stabilize food commodity prices, and increase yields and incomes.

In 2011, in the aftermath of a soil insect pest outbreak that devastated crops nationwide, the Rwanda Agriculture Board (RAB) and Ministry of Agriculture (MINAGRI) contacted CABI in Africa and Switzerland for assistance.

What did CABI do?

With established experience in facilitating South-South cooperation, CABI was in a good position to transfer and adapt Chinese technology through its experts in Switzerland and Kenya along with the Joint Laboratory for Biosafety in

China – jointly managed by CABI and the Chinese Ministry of Agriculture (MoA). Application of beneficial insect-killing (entomopathogenic) nematodes (microscopic worms that live in soil) as biocontrol agents for soil pests had previously been extensively researched by Chinese and Swiss CABI staff, together with European and Chinese companies. Subsequently, the team had successfully set up and adapted 29 nematode mass production factories across the Democratic People's Republic of Korea (DPRK).

In response to RAB's request, a team of experts was assembled under the AgriTT Biocontrol Soil Pests Project comprising CABI staff from China, Kenya, Switzerland and the UK, along with staff from the Institute of Plant Protection of the Chinese Academy of Agricultural Sciences (IPP-CAAS) and the Guangdong Entomological Institute (GEI, China). This triangular collaboration aimed to make low-input, environmentally-friendly and economically-sustainable plant protection technologies, originating from China, accessible to farmers in Rwanda, resulting in the protection of key vegetable crops from soil insect pests and increased agricultural productivity. Financed by the UK Department for International Development (DFID)'s Research Challenge Fund of the AgriTT programme, the project ran from January 2014 to March 2016.

Partners in the successful cooperation

1. MoA-CABI Joint Laboratory for Biosafety coordinated all partners.

2. RAB was the primary project beneficiaries, leading baseline data acquisition and evaluation with support from CABI Kenya and UK. They were responsible for field and laboratory work, with support from IP -CAAS, GEI, and CABI China and Switzerland. RAB staff and extension workers, and farmers, received training on soil insect pest identification and control techniques including the novel use of beneficial nematodes as biocontrol agent
3. GEI led the adaptation of biocontrol technology for production and application, and led the establishment of the new biocontrol factory by RAB in Rwanda, with support from CABI staff from China and Switzerland.
4. IPP-CAAS led the development of integrated pest management (IPM) tools for Rwandan conditions with support from RAB, GEI, CABI in Kenya and Switzerland and was responsible for surveys and identification of soil insect pests and control options.

Project partnerships, activities and outputs

Soil pest control needs and identification

Partnership: Lead RAB, with CABI and IPP-CAAS

Activities/outputs: Activities/outputs: Baseline data acquisition and analysis determined the socio-economic status and soil-pest control needs of smallholder farming communities in Rwanda and surrounding countries. RAB staff were trained on survey methods and questionnaires were developed for, and administered to, households, traders, consumers, agro-dealers and key informants from southern, eastern and northern Rwanda. The results clearly indicated a high demand for soil insect pest control in Rwanda. Over 1,000 soil insect pest samples were collected; larvae of more than 40 different species were identified using molecular tools; laying the foundation for efficiently targeting key soil insect pests with mass-produced beneficial nematodes. The identification results showed that the dominant soil insect pests in Rwanda are white grubs (Scarabeid beetle larvae: *Copris, Oniticellus, Onitis, Onthophagus, Pachysoma, Anomala, Lepadoretus, Adoretus, Cyclocephala, Pycnoschema, Hoplochelus, Melolonthini, Maladera, Trochalus* and *Lepiserica* spp.), followed by cutworm (*Agrotis* species) and bean-fly *Ophiomyia* species).

Biocontrol technology transfer and adaptation, and establishment of mass production facility

Partnership: Lead GEI, with RAB and CABI

Activities/outputs: With support from European experts, GEI set up a beneficial nematode production factory –based on a Chinese design and methodology – at RAB's Rubona station. Chinese beneficial nematode production and application technology was adapted to Rwandan conditions through a set of trainings and practical implementation activities. A total of 11 Rwandan experts (six men and five women) were trained in beneficial nematode mass production in the local factor over three-week production cycles including screening, maintenance, bacteria and beneficial nematode production, storage and field application.

Three Rwandan experts received training on beneficial nematode mass production and IPM in China; six newly-trained local experts conducted surveys for local beneficial nematodes in semi-natural and smallholder farming habitats in 10 districts of three provinces. This led to the isolation of nine local beneficial nematodes, four of which were identified, maintained,

screened and mass produced. These are the first ever beneficial nematodes isolated from Rwanda.

The team established protocols for screening virulence and propagation of beneficial nematodes. Nine beneficial nematode species/strains were isolated and five successfully identified and four successfully maintained; among those isolated were *Steinernema carpocapsae*, *Heterorhabditis bacteriophora*, two new steinernematid species and one new unnamed heterorhabditid species. These are the first records of naturally occurring beneficia nematodes in Rwanda. It is also the first record of *S. carpocapsae* in Africa. These nematodes are mass produced for effective, safe and environmentally-benign soil insect pest control.

Development of IPM tools

Partnership: Lead IPP-CAAS, with RAB, CABI and GEI

Activities/outputs: Existing literature on IPM practices was reviewed to develop a suite of proposed practices that include beneficial nematode application and ensure their effectiveness in Rwandan conditions. RAB developed, adapted and tested a number of IPM tools including crop rotation, use of beneficial nematodes, manual hand-picking of insect pests or damaged crop parts and, as a last resort, use of soil pesticides. IPP-CAAS and CABI staff from Kenya conducted training at the Rubona station and through four farmer demonstrations. Field trial protocols and operational plans were developed and compiled. Five field trials were established in southern, eastern and northern Rwanda to determine the effectiveness of beneficial nematodes against white grubs, cutworm and bean-fly. The team regularly assessed soil insect pest damage and drafted a manuscript on IPM of soil insect pests in East Africa.

Technology dissemination and scale-out

Partnership: Lead CABI, with RAB

Activities/outputs: CABI and RAB developed a dissemination strategy for beneficial nematode technology across Rwanda, and initiated dissemination and scale-out. The biocontrol technology was exhibited at the 2015 Rwanda Agri-Show in Kigali, shared at stakeholder workshops, and demonstrated to farmers and students at various events. Publicity materials were developed to raise awareness of the technology.

Challenges

The project faced a number of challenges including difficulties in obtaining local information related to soil insect pests, mainly due to limited research conducted in East Africa. Each geographic region has its own soil insect pest complexities and biocontrol solutions have to be tailored with those complexities in mind. A lack of information on target soil insect pests, therefore, makes it difficult to tailor effective biocontrol solutions against those pests. For instance, information on soil insect pest life-cycles was limited, yet this information is critical to the timing of biocontrol applications. Another challenge was that RAB lacked adequate resources to pre-finance project activities (as requested by the AgriTT funding mechanism). Nonetheless, a huge number of significant achievements were made considering the short time period of the project.

Achievements

- Capacity building of the Rwandan plant health sector, successfully enabling the country to:

- conduct research on soil insect pests and their biological control agents such as beneficial nematode
- set-up and adapt a biocontrol agent mass production factory
- produce beneficial nematode-based biocontrol agents for insect pest control
- train farmers in beneficial nematode application
- initiate the development of legislation for local biocontrol agent use
- none of the above existed in-country before the project

- Soil insect pest control technology successfully transferred from China to Rwanda:

  The first biocontrol agent mass production factory for insect pest control was established and locally adapted making biocontrol products against soil insect pests available for the first time in Rwanda. This factory is an essential step forward in Rwanda's rising expertise in biocontrol of agricultural pests, serving as a model for future scale-out, and also as a platform for Rwanda to conduct research in cooperation with neighbouring countries.

- Important strides made in soil insect pest control in Rwanda:
  - nine local beneficial nematode isolates found, five new species/strains identified and scree
  - four local beneficial nematodes and three international nematodes mass produce
  - 42 different soil insect species from the Scarabidae family (white grub) collected and identified
  - bioassay tests conducted to ascertain each novel nematode's potential in the biocontrol of white grubs and bean flies

- IPM technology successfully showcased through:
  - six field trial
  - four field demonstrations and event
  - three international conferences
  - one national Rwanda Agri-Show
  - four published scientific papers and two more in preparation
  - five posters, two leaflets, one photo-sheet, five farmer factsheets in English and Kinyarwanda, and one video
  - six green-yellow lists (IPM decision guides to help select the correct kind of pest control method for a given situation)
  - coverage on Rwandan radio and TV
  - over eight news articles (magazines/web)

- Impact on smallholder livelihoods:

  Field application trials of nematodes reduced 70 to 90 % of grubs, and indicate a 20-30% prevention of damage and losses caused by soil insect pests to vegetable production, meaning nematode-based biocontrol could potentially stabilize yields and incomes, which will improve smallholder farmer livelihoods. With increased capacity to mass produce and use beneficial nematodes for soil insect pest control in vegetables, losses in smallholder vegetable production could be further reduced and food security improved. Moreover, adverse health effects of toxic soil pesticides are eliminated by replacing such products with safe beneficial nematode-based biocontrol products.

Lessons learned

A two-year project is too short to effectively disseminate and scale out results to benefit smallholder farming communities in a significant way. A further two years would have enabled the team to consolidate the successes of the first two years by registering the biocontrol agent in Rwanda and moving towards commercialization.

The way forward

Although beneficial nematode technology has been successfully transferred to Rwanda, there is still some important work to be done to consolidate the gains made during the project and to ensure that the technology transfer translates to better results and livelihoods for Rwandan smallholder farmers. This includes:

- Implement further mass production cycles to consolidate beneficial nematode production.
- Extend demonstration plots to reach more farmers.
- Run more field trials to confirm positive results, register the biocontrol agents, initiate the commercialization process and scale-out the technology to more smallholders.
- Conduct impact studies.
- Disseminate the technology via the Rwanda Plantwise network (conduct plant doctor trainings, produce factsheets, and archive green-yellow lists of plant protection measures in Rwanda's Plantwise knowledge bank and other databases).
- Conduct screenings of nematodes to control other insects.

Publications

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