Darwin Initiative Main & Extra Annual Report

To be completed with reference to the "Project Reporting Information Note":
(https://www.darwininitiative.org.uk/resources/information-notes/)

It is expected that this report will be a **maximum of 20 pages** in length, excluding annexes)

Submission Deadline: 30th April 2025

Submit to: BCF-Reports@niras.com including your project ref in the subject line

Darwin Initiative Project Information

Scheme (Main or Extra)	Darwin Initiative Main
Project reference	**29-012**
Project title	Protecting biodiversity through biocontrol of papaya mealybug in East Africa
Country/ies	Kenya, South Sudan, Uganda
Lead Organisation	CABI
Project partner(s)	Kenya Plant Health Inspectorate Service (KEPHIS), Kenya Agricultural and Livestock Research Organization (KALRO), National Museums of Kenya (NMK), National Agricultural Research Organization (NARO), University of Juba (UoJ)
Darwin Initiative grant value	**£501,479.00**
Start/end dates of project	1. June. 2022 – 31. March. 2025
Reporting period (e.g. Apr 2024 – Mar 2025) and number (e.g. Annual Report 1, 2, 3)	April 2024 - March 2025; Annual Report 3
Project Leader name	Ivan Rwomushana
Project website/blog/social media	https://www.cabi.org/projects/biocontrol-of-papaya-mealybug-in-east-africa/
Report author(s) and date	Ivan Rwomushana, Caroline Nankinga, Wanja Kinuthia, Johnson Nyasani, Alexandar Muvea, Harrison Rware, Josiah Achieng, Monica Kansiime, Wanjiku Kiarie, Fernadis Makale. 30. April. 2025

1. Project summary

The project aimed to address biodiversity challenges related to the invasion of papaya mealybug (PMB) in East Africa (EA). PMB is an invasive pest native to the Americas and has spread rapidly in East Africa between 2015- 2022, causing significant average yield loss of up to 57% (and potentially 100% without intervention) and household economic losses estimated at £2,224/ha annually. Management of PMB by farmers in EA has largely relied on the use of pesticides, some of which are highly hazardous. Excessive use of pesticides is the second most important driver for the worldwide decline in insect populations, negatively impacting insect biodiversity by eliminating native pollinators and natural enemies of pests. Resource-limited smallholder

farmers, especially women, are most affected by biodiversity loss as they are most directly dependent on insect pollinators for their crop production.

Since 2022, with funding from the Darwin Initiative, CABI and its partners have collaborated to manage this pest through the use of the encyrtid wasp (*Acerophagus papayae*) - a biological control agent – as part of an Integrated Pest Management (IPM) strategy for the papaya mealybug in Kenya, also aiming to conserve native insect biodiversity. Classical biological control (CBC) of PMB has been recognised as a sustainable control measure through stakeholder activities under a Darwin-funded project. Following successful efficacy and quarantine tests, regulators in the three countries approved the field release of the wasp, which will reduce pesticide use and protect ecosystem health by preserving insect diversity. The introduction of the parasitoid will decrease the heavy reliance on pesticides and protect native insect diversity, ensuring a healthier ecosystem.

The project is relevant for farmers, consumers, and the environment. For resource-limited farmers, particularly women who often manage subsistence horticultural crops, biological control offers an affordable and sustainable alternative to chemical pesticides, reducing crop losses and increasing household food security. Consumers benefit from safer produce with reduced pesticide residues, while the environment gains from lowered chemical input and preserved insect biodiversity.

These challenges were identified through scientific studies and stakeholder consultations in the implementing countries. Predictions indicate that without sustainable management, PMB will continue to spread rapidly across new areas in East Africa. Recent studies in Kenya and Uganda show positive farmer attitudes towards biological control agents, highlighting the need for sustainable control measures. The project has been undertaken in PMB-infested farms in Kenya, Uganda and South Sudan (Fig.1). Following successful interventions in the regions indicated on the map, nationwide field release permits have been granted in Kenya, indicating a greater demand for this approach by the farming community.

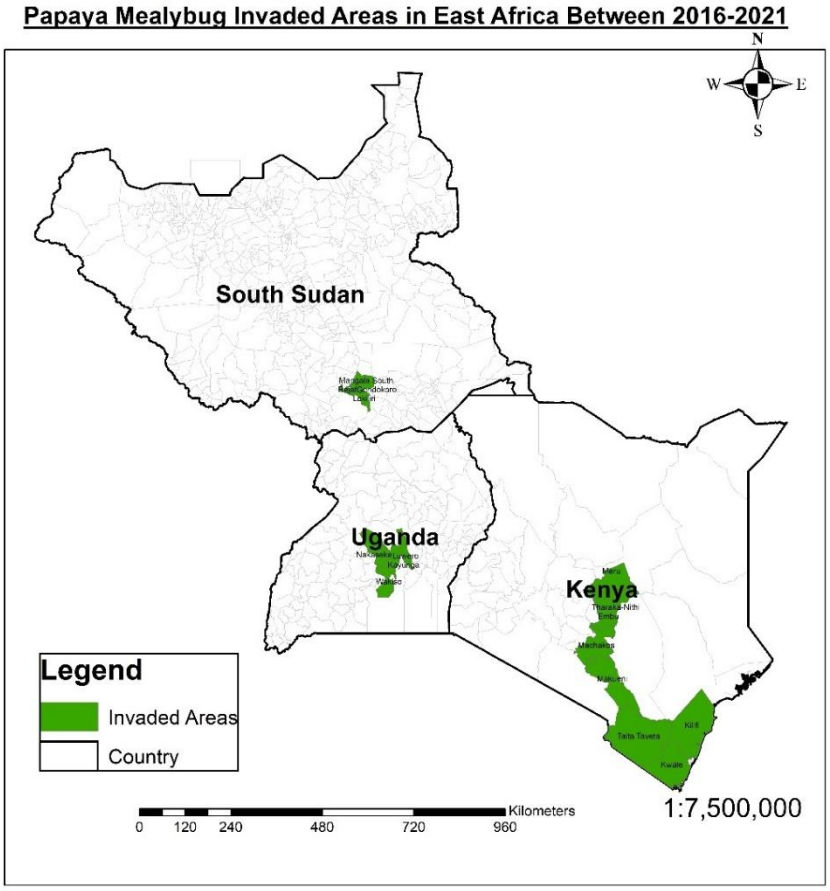

Figure 1: Papaya invaded areas in Kenya, Uganda, and South Sudan

2. Project stakeholders/ partners

The main partners under this project are KEPHIS (National Plant Protection Organisation, Kenya), NARO, KALRO, and NMK (research organisations), and UoJ (public university, South Sudan), established through in-country demand and initial consultations for PMB management in East Africa. All partners actively engaged in project planning, decision-making, and reporting (Y2 Review and Planning Report). Regular Zoom/phone meetings were held for the period under review to review progress and address any arising issues in the implementation of the project. Sub-grant contracts were signed by all except NMK (direct CABI spending), with payments phased after submission and approval of expense accountabilities by each partner (See table 1).

Table 1: Sub-grant agreement status by the DI partners.

Institution	Y1	Y2- Addenda	Y3- Addenda
KALRO	• Signed sub-grant agreement	• Signed sub-grant agreement	• Signed sub-grant agreement
KEPHIS	• Signed sub-grant agreement	• Signed sub-grant agreement	• Signed sub-grant agreement- CABI spending directly (Y3)
NARO	• CABI spending directly	• Signed sub-grant agreement	• Signed sub-grant agreement
UoJ	• Signed sub-grant agreement	• Signed sub-grant agreement	• Signed sub-grant agreement
NMK	• Not signed- CABI spending directly	• Not signed- CABI spending directly	• Not signed- CABI spending directly

Collaboration was central to all project activities across the three countries. For instance, CABI and KEPHIS jointly assessed PMB damage in Baringo, enabling emergency parasitoid release (Approval 1). Partners in Kenya, South Sudan, and Uganda jointly conducted capacity building for extension officers and farmers. In Kenya, all partners jointly participated in plant health rallies for PMB biocontrol awareness. Joint field releases and monitoring occurred in all three countries, with data and progress report submitted to KSTCIE for nationwide release suggesting confidence in the program from the higher infested areas (Report 1, Approvals 2 and 3). CABI, NMK, and NARO jointly conducted endline biodiversity assessments in Kenya and Uganda (Reports 1 and 2). All partners in Kenya participated in the post-release assessment on spread and establishment of the parasitoid in Kenya (Report 3).

Beyond formal partners, close collaboration with extension departments in Kenya, Uganda, and South Sudan facilitated farmer mobilization, plant health rallies, field releases, and monitoring. Farmers and community leaders were key in peer-mentorship, accelerating adoption and reducing pesticide use. Plant health rallies, alongside farmer and extension training on the PMB biocontrol-biodiversity link, raised awareness on biodiversity and poverty using mini-factsheets, posters, and flyers distributed in Kenya. The rally approach, using public address systems in markets and farmer gatherings, engaged broader communities on biocontrol and biodiversity, promoting IPM adoption (see BTORs 1-4; Report 5).

3. Project progress

Output 1: The *A. papayae* parasitoid released and naturalized in East Africa for the sustainable biological control of papaya mealybug and protection of native insect biodiversity.

Activity 1.1: Conduct ecological niche modelling to evaluate the environmental suitability for A. papayae across East Africa to identify potential release areas.

Ecological niche modelling was performed for *A. papayae* in Africa (including project countries- Kenya, South Sudan and Uganda) to evaluate the suitability of environmental conditions for its establishment in relation to areas invaded and/or with the potential to be invaded by PMB. This was reported on in AR2. The results of the modelling are now published in Biological control journal (https://doi.org/10.1016/j.biocontrol.2024.105628) (Paper 1).

Activity 1.2: Undertake a baseline study at selected biological control learning sites to determine the native insect biodiversity under farmers' practices

Baseline biodiversity assessments using standard protocols were conducted in Kenya, Uganda, and South Sudan, with insect and plant biodiversity reports and checklists detailed in AR1 and AR2. Following parasitoid release, endline assessments in Kenya and Uganda (Reports 7-8; BTOR 5) noted changes in insect diversity in sampled areas. It is worth noting that, after parasitoid release, most farmers significantly reduced pesticide use. No endline surveys were carried out in South Sudan due to escalating insecurity and political instability limiting field travel and associated activities.

Activity 1.3: Conduct area-wide releases of A. papayae in Kenya, South Sudan and Uganda using hand releases and deploying technology such as drones and landscape scale, Y3 Q3

In the reporting period, several mass releases (including augmentation) of the parasitoid were undertaken in Kenya, South Sudan and Uganda. The releases were done on over 500 farms (See- FR1- 5, Report 5, Data 2). Following KSTCIE approval for an additional five counties in Kenya (Approvals 1 & 2), more releases occurred reaching more farmers in Kenya. Additionally, with the nationwide approval (Approval 4), the release of the parasitoid will continue beyond the life of this project. While releases in Kenya and Uganda focussed more on papaya fields, in South Sudan, releases covered other crops- cassava, hibiscus and okra that are economically important in the country and cultivated on a large scale compared to papaya. Field releases were conducted by hand using parasitised mummies reared in the CABI biocontrol labs (Kenya and South Sudan) and NARO labs in Uganda. This in-country rearing capacity ensured a consistent supply of the biological control agent for the release programs.

Activity 1.4: Establish A. papayae reservoirs on farmers' fields for parasitoid mass production in situ for augmentative field releases during naturalization, Y1 Q3; Y2 Q2 and Y3 Q3

Initially intended to aid the establishment of parasitoids in the field, this activity, despite being part of the farmer training, was discontinued after the second year as the parasitoid showed high establishment rates without Natural Enemy Field Reservoirs (NEFRs). However, trained farmers and local extension agents have gained knowledge on NEFRs, including monitoring parasitoid populations and may be able to implement augmentative biocontrol when deemed necessary. The NEFRs helped the farmers to understand the concept of conserving the biological control agents. In Uganda, farmers carried mummies on leaves from one district to another hastening the spread. The findings of the role of NEFRs in PMB management has been published in the Biocontrol journal (https://doi.org/10.1016/j.biocontrol.2024.105528) - (Paper 2).

Activity 1.5: Conduct monitoring to determine post-release establishment and parasitoid efficacy as well as expansion outside the release areas, Y1 Q3; Y2 Q2; Y3 Q1, Y4 Q4

Post-release monitoring in the release sites confirmed the successful establishment of the parasitoid. Further, the monitoring efforts have documented the natural dispersal of the parasitoid beyond the initial release points. Notably, the parasitoid has been observed to have spread outwards by over 100 KM from the original release locations in both Kenya and Uganda (Reports 2-5). This natural dispersal is a crucial indicator of the parasitoid's ability to effectively locate and control PMB populations across a wider geographical area without further human intervention. In the field, direct evidence of parasitoid activity has been consistently observed, indicating successful parasitism. Furthermore, live adult parasitoids have also been sighted actively searching for and parasitizing PMB on papaya plants in the release areas and surrounding fields.

Crucially, the monitoring data reveal a significant reduction in the populations of the papaya mealybug in areas where the parasitoid has been released and established. This direct correlation between parasitoid presence and PMB decline strongly confirms the efficacy of *Acerophagus papayae* as a biological control agent for this invasive pest in East Africa. The effectiveness of the parasitoid has also been corroborated by the experiences of practicing farmers in the release areas. Their testimonials, documented in project blogs and reports from Uganda, consistently highlight a noticeable decrease in PMB infestations and a subsequent improvement in the health and yield of their papaya crops following the parasitoid releases (Reports 1-5, blogs).

Output 2: Capacity of crop inspectors, small-holder farmers, extension providers and the general public enhanced on in situ management of A. papayae on sustainable management of papaya mealybug and biodiversity conservation

Activity 2.1: Train crop inspectors in the identification of papaya mealybug and related scale insects, the A. papayae parasitoid and the biological control-biodiversity conservation nexus, Y1 Q2; Y2 Q1; Y3 Q4

Crop inspectors in Uganda and South Sudan received training on PMB identification (symptoms and damage) and management, emphasizing biocontrol, NEFRs, and in-situ production/conservation (see training materials). The training also covered PMB spread factors, similar scale insects, PMB natural enemies (predators, parasitoids), lab rearing of PMB and its parasitoid, comprehensive PMB management strategies, and parasitoid conservation in the field. A total of 20 (19 M:1 F) inspectors were trained. Additionally, as part of the project's gender integration efforts, a tailored gender training module—developed in line with the project's gender strategy—was delivered to all participating trainees across the three target countries (see BTORs 3, 4, FR5 and blog). The objective of the training was to equip plant health inspectors with the knowledge and tools to support gender-responsive communication and ensure inclusive outreach that addresses the specific needs, constraints, and roles of both male and female farmers in pest management and advisory services.

2.2: Train extension workers and community facilitators on conservation of A. papayae in the field, to support the process of naturalization, Y1 Q3; Y2 Q2, Y3 Q1, Y4 Q3

In the reporting period, 106 (61M: 45F) extension workers and community facilitators were trained on various aspects of PMB biocontrol (similar topics to those of inspectors) in the project countries (BTORs 1-4, Report 5 and Data 1). This followed the approval of additional release counties in Kenya. Subsequently, these trained individuals supported field releases and parasitoid monitoring, farmer mobilization and selection, and plant health rallies promoting PMB biocontrol and biodiversity conservation.

2.3: Train farmers on in situ production of A. papayae in their farms, Y3 Q3

During the reporting period in Kenya and Uganda, trainings focused on PMB biocontrol, in-situ parasitoid production, and biodiversity considerations in pest management were conducted for farmers. In Kenya, following authorization for parasitoid release in an additional five counties, 624 farmers (313 male; 311 female) received targeted training (refer to BTOR 1-4 and Data 1). Furthermore, plant health rallies were held across Machakos, Makueni, Baringo, Tharaka Nithi, and Embu Counties. These successfully sensitized a total of 2661 participants (1485 male; 1176 female) from the farming community and the general public (BTORs 2, 9; Data 1 and Report 4). Relevant PMB photosheets, factsheets, and booklets were distributed to attendees during these events. Furthermore, the PMB biocontrol project was showcased at the KALRO Kilimo Biashara Expo, engaging a wide array of stakeholders. The 2025 Expo had over 5000 participants from Kiambu, Murang'a counties, and beyond, including researchers, business people, policymakers, farmers, and students. At the Darwin initiative-sponsored booth, attendees were informed about the biocontrol efforts in Kenya, generating interest among farmers facing challenges with the PMB infestation (See BTOR 7). In Uganda, 51 participants (22 female and 29 male), comprising seven agricultural extension staff from scale-out districts and sub-counties, as well as farmers from Nakasongola, Kamuli, Hoima, Masaka, Nakaseke, Kayunga, and Luwero, underwent training on PMB biocontrol and parasitoid conservation. Consistent with the approach for

extension officers, farmers also benefited from a concurrently delivered, tailored gender training component integrated within the technical curriculum (See Report 5 and BTOR 4-5). Unfortunately, due to gathering restrictions occasioned by political instability in South Sudan, farmer training only happened for the beneficiaries of the parasitoids on-farm.

Output 3: Scientific evidence-base generated on impacts of classical biological control of *A. papayae* on livelihoods and native insect biodiversity

Activity 3.1: Undertake surveys to establish the effect of pesticide use on native insect biodiversity, comparing fields with and without the parasitoid, and fields with farmers pesticide practices, Y1 Q1; Y1 Q3; Y2 Q1; Y2 Q3; Y3 Q1; Y3 Q3

This activity, conducted in Years 1 and 2 and detailed in AR2, yielded findings on Natural Enemy Field Reservoirs (NEFRs). These findings, published in the Biocontrol Journal (Paper 2), demonstrated increased natural enemy abundance and diversity in farmers' fields, alongside enhanced parasitism in treated sites. Endline biodiversity assessments in biological learning sites (following complete pesticide withdrawal) indicated significant shifts in insect diversity compared to pre-parasitoid release conditions (refer to BTOR 5 and Reports 2- 8).

Activity 3.2: Conduct socio-economic studies to determine the impacts of the CBC approach on the population of papaya mealybug and crop infestation, Y3 Q3

Following approval by National Commission for Science, Technology and Innovation (NACOSTI) and CABI Ethics and Review Board (ERB) (See Approvals 5 and 6), a survey is currently underway to quantify the impacts of CBC in Kenya. At the time of reporting, data collection is underway in the field (see data collection tool- Tool 1). However, preliminary post-release observations and farmer feedback confirm a reduced PMB population in treated fields and improved yield (see Report 5).

Activity 3.4: Generate an inventory of native insect biodiversity pre-and post-release of A. papayae to determine the positive impacts of the classical biological control programme on insect biodiversity; Y1 Q1; Y1 Q4; Y2 Q3; Y3 Q2

Baseline biodiversity assessments have been conducted in all the implementing countries (Ref to Activity 1.2). An inventory (baseline) of native insect and plant diversity has been developed for all countries (Refer to the biodiversity reports reported in AR2). Endline post-release biodiversity assessment was also conducted in biological learning sites in Kenya and Uganda (refer to Reports 2, 3, 7, 8; BTOR 5). One crucial finding was that the encyrtid *Pseudleptomastix mexicana* Noyes and Schauff was recovered for the first time from the papaya mealybug, suggesting an increase in other parasitoids for this pest. Endline assessment in South Sudan was not carried out due to security concerns in the country.

Activity 3.5: Conduct surveys to establish impacts of the classical biological control agent on non-target scale insects, Y3 Q3

Post-release monitoring in the release and learning sites did not observe any impacts of the parasitoid to non-target scale insects or any other organism apart from the PMB. Furthermore, following the reduction and/or withdrawal of pesticides after parasitoid release, increased diversity of native insects, including beneficial natural enemies of the PMB, such as ladybird beetles was observed in Kenya and Uganda (See Reports 4- 5 and 8).

Output 4. Information on classical biocontrol of papaya mealybug and conservation biocontrol approaches to support natural pest regulation and better management of biodiversity packaged and disseminated to increase farmer knowledge and technology adoption

4.1: Develop an effective, gender responsive communication plan, integrating multi-channel communication approaches appropriate for reaching men and women smallholder farmers, Y1 Q3

A gender and communication strategy was developed in Y2 (Ref AR2), providing a structured framework to mainstream gender considerations and enhance the effectiveness of

communication efforts across project activities (see FR5, BTOR 1 and 4). In Y3, the strategy was operationalised through a series of deliberate interventions aimed at promoting inclusive participation and equitable access to knowledge and resources. Key components of the operationalisation included: customized training modules designed and delivered to plant health inspectors, extension workers, and farmer representatives across the three project countries; all communication outputs, including factsheets, pest management decision guides (PMDGs), photo sheets etc, were reviewed and adapted to reflect gender-sensitive messaging; the strategy guided outreach activities to ensure the active involvement of women farmers, who are often underrepresented in conventional extension systems; and development of gender-sensitive indicators and disaggregated data collection tools, enabling the project to track gendered outcomes and adapt approaches based on emerging evidence.

4.2: Produce and disseminate different information products on targeting different stakeholders on dual purpose - pest control and biodiversity conservation nexus, Y4 Q4

Over 1000 products produced in Y2 were distributed to relevant stakeholders. They Include PMB factsheets, PMDG, Photosheets, papaya diseases and a pocket guide and training manual for extension officers. Two TV broadcast on PMB biocontrol work were also highlighted in Kenya and Uganda. The project web-page was also updated https://www.cabi.org/projects/biocontrol-of-papaya-mealybug-in-east-africa/. During the same period, 29 pieces of media coverage (blogs, news articles, social media etc.) were published by various outlets (see Press 1). Additionally, two journal articles were published and three abstracts were presented at the Association of African Insect Scientists (AAIS) in Y3.

Publications.

1) Potential distribution of *Acerophagus papayae*, a parasitoid of the papaya mealybug (*Paracoccus marginatus*), across Africa- Biological Control https://doi.org/10.1016/j.biocontrol.2024.105628 - (Paper 1).
2) Unleashing nature's defenders: Farmer-managed natural enemies field reservoirs (NEFRs) enhance management of the invasive papaya mealybug (*Paracoccus marginatus*) in coastal Kenya- https://doi.org/10.1016/j.biocontrol.2024.105528 - Biological Control (Paper 2).
3) Three abstracts presented at the Association of African Insect Scientists (AAIS) held in Lusaka, Zambia (See abstracts 1-3).

Blogs and news articles.

1) https://www.fao.org/world-food-day/food-heroes/detail/alfred-bolo/en
2) https://www.scidev.net/global/news/wasps-help-farmers-fight-mealybug-pest/
3) https://news.scienceafrica.co.ke/kenya-cabis-biocontrol-agent-effective-against-papaya-pest/
4) https://news.scienceafrica.co.ke/kenya-cabis-biocontrol-agent-effective-against-papaya-pest/
5) Scientists unleash thousands of wasps to save Kenya's pawpaws (the-star.co.ke)
6) Scientists release wasps to save Kenya's pawpaws from the papaya mealybug (freshplaza.com)
7) CABI leads fight against dangerous papaya mealybug in Kenyan farms (biznakenya.com)
8) CABI and Partners Expand Efforts to Combat Papaya Mealybug in Kenya | Kenyans.co.ke
9) CABI and Partners Step Up Fight Against Devastating Papaya Mealybug on More Farms in Kenya (krishakjagat.org)
10) https://blog.invasive-species.org/2024/08/12/south-sudan-smallholder-farmers-embrace-natures-solution-to-papaya-mealybug-menace/
11) https://www.cabi.org/news-article/workshop-outlines-plan-to-increase-fight-the-devastating-papaya-mealybug-pest-in-more-locations-across-uganda/
12) https://blog.invasive-species.org/2024/12/12/cabi-led-study-shows-potential-distribution-of-natural-enemy-for-papaya-mealybug-pest-across-africa/

13) https://blog.cabi.org/2024/06/13/insect-wasps-are-my-army-in-the-fight-to-protect-my-pawpaw/
14) https://blog.plantwise.org/2024/10/01/what-are-natural-enemies-field-reservoirs-and-how-do-they-help-farmers-control-crop-pests/
15) https://www.cabi.org/news-article/cabi-and-partners-step-up-fight-against-devastating-papaya-mealybug-on-more-farms-in-kenya/
16) https://www.cabi.org/news-article/sustainable-biological-control-agent-approved-to-fight-papaya-mealybug-pest-across-kenya/
17) https://blog.plantwise.org/2024/02/23/how-a-tiny-wasp-can-save-the-livelihoods-of-papaya-farmers/
18) https://www.en.krishakjagat.org/biologicals/sustainable-biological-control-agent-approved-to-fight-papaya-mealybug-pest-across-kenya/
19) https://www.freshplaza.com/africa/article/9696845/kenya-deploys-parasitoid-wasp-to-combat-papaya-mealybug/
20) https://www.the-star.co.ke/news/2025-02-03-kenya-approves-release-of-wasps-to-kill-pawpaw-pest
21) https://news.agropages.com/News/NewsDetail---52743.htm
22) https://peopledaily.digital/news/bio-control-agent-approved-to-fight-papaya-mealybug-pest
23) https://www.cabi.org/news-article/workshop-outlines-plan-to-increase-fight-the-devastating-papaya-mealybug-pest-in-more-locations-across-uganda/

TV and YouTube broadcasts.

1) Papaya mealybug management in Kenya
2) Papaya mealybug management in Uganda

In 2024, the PMB biocontrol work garnered significant media attention across the region, totalling 29 online, offline, and social media coverage pieces. This coverage reached an estimated combined audience of 26.1 million, with approximately 143,000 views and 19,400 engagements (likes, shares, and comments on social media platforms), significantly boosting awareness of these sustainable biocontrol practices. Detailed metrics on this media/press coverage are available here: https://cabi.coveragebook.com/b/9f1419b0072ffc41#metrics-summary – (Press 1).

3.1 Progress in carrying out project Activities

Activity	Progress in Y3
1.1: Conduct ecological niche modelling to evaluate the environmental suitability for *A. papayae* across East Africa to identify potential release areas, Y1 Q3	1.1. Modelling completed, results published in Biocontrol journal (Paper 1).
1.2: Undertake a baseline study at selected biological control learning sites to determine the native insect biodiversity under farmers practices, Y1, Q3	1.2. Baseline and endline studies completed in biological learning sites in Kenya and Uganda. Not done in South Sudan due to insecurity and political instability in the country. (Reports 7-8; BTOR 5).
1.3: Conduct area-wide releases of *A. papayae* in Kenya, South Sudan and Uganda using hand releases and also deploying technology such as drones and landscape scale, Y3 Q3	1.3. Multiple field releases conducted in all countries (see FR 1-5, Report 4-5, Data 2 and 3)
1.4: Establish *A. papayae* reservoirs on farmers' fields for parasitoid mass production in situ for augmentative field releases during naturalization, Y1 Q3; Y2 Q2 and Y3 Q3	1.4. In Y3, no more NEFRs were established as the parasitoid demonstrated high establishment rates even the need for NEFRs. Farmers were however, still trained on in-situ production of the parasitoid and have knowledge and skills on NEFRs, including monitoring parasitoid populations and may be able to implement augmentative biocontrol when deemed necessary

1.5: Conduct monitoring to determine post-release establishment and parasitoid efficacy as well as expansion outside the release areas, Y1 Q3; Y2 Q2; Y3 Q1, Y4 Q4	1.5. Multiple post-release monitoring were conducted; all confirmed establishment and spread of the parasitoid (see Reports 1-5, blog).
2.1: Train crop inspectors in identification of papaya mealybug and related scale insects, the *A. papayae* parasitoid and the biological control-biodiversity conservation nexus, Y1 Q2; Y2 Q1; Y3 Q4	2.1. 20 (1 female) crop inspectors were trained in South Sudan (FR 5)
2.2: Train extension workers and community facilitators on conservation of *A. papayae* in the field, to support the process of naturalization, Y1 Q3; Y2 Q2, Y3 Q1, Y4 Q3	2.2. About 106 (45 females) and 7 (4 females) were trained in Kenya and Uganda, respectively (BTORs 1-4, Report 5 and Data 1).
2.3: Train farmers on in situ production of A. papayae in their farms, Y3 Q3	2.3. 624 (311 females) and 44 (18 females) extension officers were trained in Kenya and Uganda (refer to BTOR 1-4, Report 5 and Data 1). Further, over 2661 (1176) were sensitised via plant health rallies. (BTORs 2, 9; Data 1 and Report 4)
3.1: Undertake surveys to establish the effect of pesticide use on native insect biodiversity, comparing fields with and without the parasitoid, and fields with farmers pesticide practices, Y1 Q1; Y1 Q3; Y2 Q1; Y2 Q3; Y3 Q1; Y3 Q3	3.1. Post-release monitoring and biodiversity conducted; increase native insect observed (refer to BTOR 5 and Reports 2- 8
3.2: Conduct socio-economic studies to determine the impacts of the CBC approach on the population of papaya mealybug and crop infestation, Y3 Q3	3.2. Socio-economic survey currently underway (see data collection tool- Tool 1)
3.3: Undertake surveys to assess the impacts of *A. papayae* biological control on yield and incomes of smallholder households, Y3 Q3	3.3. Socio-economic survey currently underway to quantify this. Farmer testimonials confirm increase in yield (see Tool 1; Report 4 and blogs)
3.4: Generate an inventory of native insect biodiversity pre-and post-release of A. papayae to determine the positive impacts of the classical biological control programme on insect biodiversity; Y1 Q1; Y1 Q4; Y2 Q3; Y3 Q2	3.4. Insect biodiversity checklist developed from the endline biodiversity surveys (refer to Reports 2, 3, 7, 8; BTOR 5).
3.5: Conduct surveys to establish impacts of the classical biological control agent on non-target scale insects, Y3 Q3	3.5. Endline surveys completed in Kenya and Uganda; increased insect diversity observed in the release farms. No non-target impacts observed (refer to BTOR 5 and Reports 2- 8).
4.1: Develop an effective, gender responsive communication plan, integrating multi-channel communication approaches appropriate for reaching men and women smallholder farmers, Y1 Q3	4.1. A gender and communication strategy was developed in Y2 (ref to AR2). In Y3, tailored gender training has been conducted in all three countries for the different categories- farmers, extension workers and crop inspectors (see FR5, BTOR 1 and 4).
4.2: Produce and disseminate different information products on targeting different stakeholders on dual purpose - pest control and biodiversity conservation nexus, Y4 Q4	4.2. In Year 3, over 1000 gender-responsive technical and awareness materials were distributed to various stakeholders. Additionally, about 29 pieces of media coverage (blogs, news articles, social media engagement, TV broadcasts etc.) were published. These along with an exhibition in Kenya, further broadened outreach to a wider audience (refer to TV links, Press 1 and BTOR 2, 7 and 9).

3.2 Progress towards project Outputs

Output 1: The *A. papayae* parasitoid released and naturalized in East Africa for the sustainable biological control of papaya mealybug and protection of native insect biodiversity

To date, parasitoid field releases have occurred on over 500 farms (approximately 1000 acres of land) across Kenya, South Sudan, and Uganda, including both initial introductions and augmentation efforts. Over 2 million parasitoids have been released in the project countries (see FR 1- 5 and Data 2). Post-release monitoring (Reports 4-5 and BTOR 5) confirms successful establishment and dispersal exceeding 100 km from release sites. Notably, significant PMB population reductions are observed in both release and non-release sites with parasitoids

(Reports 4 and 5), alongside increased diversity of native natural enemies of PMB, particularly ladybird beetles and *P. mexicana* (see Reports 2, 3, 7 and BTORs 5) all of which contribute to PMB management. These post-release outcomes align with ecological niche modelling predictions of high parasitoid establishment in East Africa. Given nationwide release approval and the parasitoid's high establishment and dispersal rates in Kenya (over 100 KM), it is anticipated that the project's 75,000-hectare target for PMB control will likely be met and potentially surpassed, even beyond the project's duration.

Output 2: Capacity of crop inspectors, small-holder farmers, extension providers and the general public enhanced on in situ management of *A. papayae* on sustainable management of papaya mealybug and biodiversity conservation

In Kenya, Uganda, and South Sudan, Darwin Initiative partners collaboratively trained crop inspectors, extension providers, and farmers on PMB biocontrol, including in-situ management of A. papayae, employing innovative methods such as plant health rallies and expo exhibitions alongside traditional settings. This facilitated the rapid achievement of targets. In Year 3 alone, over 3,476 individuals (106 extension officers, 20 crop inspectors, and 675 farmers directly trained in Kenya, Uganda and South Sudan. Further about 2661 farmers (1485 M: 1176 F) were sensitised via rallies. In addition, the Darwin Initiative was showcased at The Kilimo Biashara Expo in Kenya attended by over 5000 participants. These figures surpassed set targets for all categories. Training was supported by project-developed technical materials like photosheets, training manuals, factsheets, and a pest management decision guide. These trainings have further enabled downstream activities such as plant health rallies, field releases, post-release monitoring, and broader biocontrol awareness initiatives among the trained groups in Kenya, South Sudan and Uganda (See BTORs 1-4, 7, FR 5, Report 4-5, blog).

Output 3: Scientific evidence-base generated on impacts of classical biological control of *A. papayae* on livelihoods and native insect biodiversity.

Biodiversity checklists have been developed capturing the change in the native insect diversity before and after parasitoid release (Report 7 and BTOR 5). Additionally, post-release monitoring has confirmed the establishment and natural dispersal of the parasitoid and increased natural enemy diversity in the release sites, reduced PMB populations and increased papaya production (See Reports 4, 5, 7, BTOR 5); the socio-economic survey to assess the benefit of CBC including livelihood issues is currently underway at the time of reporting; the role of NEFRs in PMB management has been published.

Output 4. Information on classical biocontrol of papaya mealybug and conservation biocontrol approaches to support natural pest regulation and better management of biodiversity packaged and disseminated to increase farmer knowledge and technology adoption

Gender-sensitive training and materials were developed to enhance farmer awareness and adoption (refer to BTORs 1- 4, 7 FR 5) for Kenya, Uganda, and South Sudan). Guided by the gender and communication strategies, technical materials were integrated into plant health rallies and farmer training to improve biocontrol understanding and uptake. The recent Kilimo Biashara Expo also provided a platform to disseminate CBC information to a broader audience in Kenya. Other communication methods, including blogs and news articles (over 10 published in Year 3) (Ref to 4.2. above) and conference presentations (three presented at the AAIS in Zambia) (see 4.2 above), have been used to further disseminate information about the Classical Biological Control (CBC) work in Kenya and the region. Over 1000 mini factsheets, PMDGs and photo-guides on PMB and its parasitoids were produced for dissemination to farmers, extension officers and community members. Additionally, media coverage in the implementing countries has highlighted key project achievements and further raised awareness about biocontrol (see TV links). These numbers exceed the project targets.

3.3 Progress towards the project Outcome

Significant progress has been made towards enhancing East Africa's capacity for climate-smart papaya mealybug (PMB) management

Indicator 0.1: Following field release, the parasitoid has been established on over 500 primary release farms (estimated 1000 acres), with successful establishment and dispersal confirmed 100 KM from the release sites (see Reports 4, 5 and BTOR 3, Data 2). While the 75,000-hectare target is yet to be fully quantified by formal post-release impact assessment, the widespread establishment and dispersal indicate substantial progress.

Indicator 0.2: Endline biodiversity assessments and post-release monitoring confirm an increased distribution, abundance, and diversity of native insect biodiversity, particularly natural enemies, in target areas. Diversity of ladybird beetles and another PMB parasitoid (*P. mexicana*) has greatly increased in the release sites (See BTORs 8, Reports 4, 5 and 7).

Indicator 0.3: Post-release monitoring indicates a reduction in PMB populations and a corresponding increase in papaya yield, suggesting progress towards the target of less than 20% yield loss. Formal quantification through ongoing socio-economic surveys is underway, however, farmer testimonials confirm this (See BTORs 8, Reports 4, 5 and 7).

Indicator 0.4: Over 3,476 individuals (106 extension officers, 20 crop inspectors, and 675 farmers directly trained, plus 2661 farmers sensitized via rallies and 134 at the expo exhibition) have been reached with information on classical biocontrol for PMB and conservation biocontrol practices. Trained extension officers, crop inspectors, and farmers have already proven beneficial by supporting PMB and parasitoid mass campaigns, facilitating parasitoid spread alerts, and aiding overall PMB management. More than 1000 gender-responsive training materials including mini factsheets and other technical material have been distributed to different stakeholders, indicating substantial progress towards the 15,000 target. During a field release activity in Baringo, project partners further created awareness on PMB management to wider audience which was broadcasted on KTN TV (one of the mainstream media outlet in Kenya (Papaya mealybug management in Kenya). Further, in Uganda, the work of PMB management was broadcasted on the national broadcaster (UBC- Papaya mealybug management in Uganda), further reaching a wider audience. Based on the viewership from the two national broadcasters, the number of people reached is estimated to be more than 4 million (YouTube Channel subscribers) with the number being higher for live broadcasts. This reporting period saw an estimated reach of 26.1 million people across the implementing countries and beyond through diverse press coverage channels, including blogs, social media, news articles, and TV broadcasts (See Press 1)

Indicator 0.5: While direct quantification of pesticide use and expenditure reduction is underway through socio-economic surveys, the observed reduction in PMB populations following parasitoid establishment strongly suggests a decreased reliance on pesticides (Reports 4, 5; Tool 1). Farmer testimonials in the primary release sites also confirmed reduction or complete withdrawal of pesticide use, indicating a reduced expenditure and production cost (Report 5).

The current indicators are adequate for measuring the intended outcome, and the underlying assumptions remain valid. While several indicators are on track for achievement or even exceeding targets, complete reporting on all indicators may not be feasible by the project's current end date. However, comprehensive data and reports for all indicators will be included in the final project report.

3.4 Monitoring of assumptions

All assumptions remain valid and none of the listed risks have impacted the outcome level.

Assumption 1: *Crop yield is not negatively impacted by factors outside the scope of the project such as adverse weather conditions, and public health concerns such as Covid-19 restrictions. Covid-19 is being mitigated by increased vaccinations that have relieved lockdowns and cessation of movement.*

Comments: Valid. No significant environmental events impacted production during this reporting period. COVID-19 is no longer a major concern in the implementing countries. In-person training proceeded normally and in Y3 plant health rallies were conducted (see BTOR 2 and 9)

Assumption 2: *Farmers are willing to take up the use of classical biological control for papaya mealybug and reduce pesticide use.*

Comments: Valid. Increased interest in scaling PMB biocontrol from farmers and devolved governments, following initial release successes, supported emergency release approval in Baringo and nationwide release permission by KSTCIE. Significant interest in Uganda prompted refurbishment of the quarantine rearing facility to support expanded mass rearing, training and release efforts (see Approval 1 and 2).

Assumption 3: *Multiple open data sources are available and accessible on parasitoid distribution for ecological modelling.*
Comments: Valid. Niche ecological modelling completed, now continental in scope, highlighting suitability of the parasitoid in relation to PMB presence or potential invasion and prevailing environmental conditions. Results published in Biocontrol Journal (refer to article in 1.1)

Assumption 4: *Permits for release of the parasitoid are obtained in a timely manner from the government agencies in charge.*
Comments: Valid. Relevant permits obtained in all the three countries. In Y3, a nation-wide approval granted to release the parasitoid in Kenya (see Approval 1-4).

Assumption 5: *Smallholder farmers and extension workers are willing to participate in the surveys.*
Comments: Valid. Farmers have shown strong engagement in the PMB biocontrol program, evident in their interest in establishing NEFRs, participating in monitoring interviews/surveys (as demonstrated by the ongoing socio-economic survey), and their willingness to adopt the biocontrol methods. Similarly, extension officers and crop inspectors have actively supported the initiative through participation in training, facilitating field releases, monitoring parasitoid spread, and contributing to awareness creation via plant health rallies (see Approval 1-4).

Assumption 6: *National stakeholders are willing to collaborate in providing information.*
Comments: Valid. Across all participating countries, stakeholders demonstrated strong support for the biocontrol efforts. Stakeholder workshops fostered buy-in and facilitated the contextualization of communication materials, including the assignment of local, farmer-friendly names for the PMB (e.g., "*Kifampa*" in Uganda, "*Ndaa Nzau*" in Makueni, Kenya) and its parasitoid (e.g., "*mutaa kifampa*" in Uganda; see Report 5).

Assumption 7: *Political and public health concerns such as Covid-19 are suitable for holding mass awareness activities.*
Comments: Partly Valid. While COVID was no longer a major concern to facilitate in-person gatherings across the three countries, the political and security situation in South Sudan continued to constrain the full implementation of activities, particularly those requiring physical presence (See training BTORs 1- 4, multiple global news)

3.5 Impact: achievement of positive impact on biodiversity and multidimensional poverty reduction

Sustainable management of papaya mealybug achieved in East Africa through biological control thereby enhancing livelihoods and protecting native insect biodiversity threatened by pesticide use

The successful implementation of biological control against the PMB across East Africa is fostering sustainable pest management, improving farmer livelihoods, and safeguarding native insect biodiversity threatened by excessive pesticide use. This reporting period witnessed multiple parasitoid releases in Kenya, South Sudan, and Uganda. Post-release monitoring indicates a notable decline in PMB populations in several hotspots, correlating with improved plant health and reduced pesticide reliance (see BTORs 5, reports 2-5). Beyond reducing production costs and increasing incomes (See Report 5), this approach has fostered an increase in native insect diversity (see BTOR 5, Reports 2-5), particularly conserving key natural enemies

in release areas, potentially contributing to long-term control of PMB and other pests. Farmer testimonials and post-release suggest improved papaya yields and farmer income, particularly among smallholders who previously suffered economic losses due to PMB infestations. Importantly, reduced pesticide application in targeted areas is expected to contribute to the conservation of native insect biodiversity and promote agroecological resilience (see reports 4, 5, 8 and BTOR 5). A wide scale study is underway to quantify the benefits and livelihood changes. Capacity-building efforts have reinforced this progress. 3,476 extension agents, inspectors, and farmers, including a substantial proportion of women have been trained on PMB identification, safe handling, and in-situ management of the parasitoid. This capacity building effort will ensure the institutionalization of knowledge for sustained PMB management practices (see BTORs 1-4, Report 4, 5). Innovative approaches like plant health rallies and exhibitions during the reporting period have contributed to increased awareness, generating more interest among the farming community (See BTORs 2, 7, 9 and TV broadcasts: Papaya mealybug management in Kenya and Papaya mealybug management in Uganda). The development of gender-responsive communication and technical materials further supports the continued adoption of these sustainable practices by various stakeholders. With the nationwide release permissions in place, it is anticipated that the engaged stakeholders (through various channels) will adopt and implement these sustainable PMB management practices across East Africa.

4. Project support to the Conventions, Treaties or Agreements

This project directly supports the CBD's biodiversity conservation objective by promoting Classical Biological Control (CBC) as an environmentally sound alternative to pesticides for invasive alien species (IAS) management. It contributes to CBD Articles 6 (Conservation and Sustainable Use), 7 (Identification and Monitoring), 12 (Research and Training), and 13 (Public Education and Awareness). Recognizing invasive species, unsustainable agriculture development, and chemical overload as key drivers of biodiversity loss, the project aims to mitigate these pressures in East Africa, aligning with National Biodiversity Strategy and Action Plan objectives. In Kenya, the project also aligns with the invasive and migratory pests and weeds strategy which aims at managing migratory and invasive pests and weeds through an integrated multi-stakeholder approach and environmentally sustainable interventions in order to enhance and improve food and nutrition security (all field release (FR 1- 5), training (BTOR 1-4), biodiversity reports and information materials (Report 2, 3, 7, BTOR 5, Products 1-3).

Furthermore, this project contributes to the Aichi Biodiversity Targets of Kenya, South Sudan, and Uganda by identifying and prioritizing invasive alien species (IAS) and their pathways, implementing control or eradication measures for priority species, and managing these pathways. This directly addresses the threat posed by invasive species to native biodiversity, as acknowledged in their National Biodiversity Strategy and Action Plans. The field releases conducted during this reporting period have specifically contributed to achieving National Target 14 – managing IAS harmful to biodiversity, socio-economic development, and human health to prevent their introduction and establishment. Moreover, the project's training of crop inspectors, extension service providers, and farmers in sustainable PMB identification and management is a crucial element in realizing these national biodiversity goals (refer to training reports). The technical materials disseminated and adoption of innovative approaches like plant health rallies and media engagement (news articles, blogs, conference, and live broadcast) have been critical in awareness creation for adoption (see BTORs, blogs, TV links and Press 1 above)

5. Project support for multidimensional poverty reduction

This project directly benefits papaya farmers in Kenya, Uganda, and South Sudan by deploying PMB biocontrol. By promoting biological control, the initiative enhanced agricultural productivity and food security through yield recovery in papaya, contributing to increased income or income recovery for farmers whose fields had been previously devastated. Farmer feedback from Uganda (see Report 5) confirms yield improvements and a return to papaya cultivation in previously abandoned fields (Bolo blog-(iii)), with anticipated positive impacts on income and poverty reduction. In Kenya, field data and farmer feedback indicate that parasitoid releases have reduced pesticide dependence, improved yields at release sites, and contributed to the

conservation of native biodiversity (see Paper 2, Report 4, 8). The observed resurgence of natural enemies such as ladybird beetles and *P. mexicana* suggests additional pest control benefits, which may further enhance crop productivity and household income.

Although long-term empirical impact assessments are ongoing (refer to 3.2), field observations and monitoring reports show strong indications of success. Parasitoid establishment has been confirmed at all release sites, ensuring sustainable, long-term PMB management. The integration of biocontrol training into national extension systems—via permanent government staff—further strengthens institutional capacity. Finally, targeted awareness campaigns are expected to increase the perceived value of biodiversity and promote broader adoption of sustainable pest management practices, reinforcing the project's contribution to reducing pest pressures and multidimensional poverty.

6. Gender Equality and Social Inclusion (GESI)

GESI Scale	Description	Put X where you think your project is on the scale
Not yet sensitive	The GESI context may have been considered but the project isn't quite meeting the requirements of a 'sensitive' approach	
Sensitive	The GESI context has been considered and project activities take this into account in their design and implementation. The project addresses basic needs and vulnerabilities of women and marginalised groups and the project will not contribute to or create further inequalities.	
Empowering	The project has all the characteristics of a 'sensitive' approach whilst also increasing equal access to assets, resources and capabilities for women and marginalised groups	X
Transformative	The project has all the characteristics of an 'empowering' approach whilst also addressing unequal power relationships and seeking institutional and societal change	

The project developed a comprehensive gender and communication strategy (reported in AR2) to mainstream gender considerations throughout all project activities. This strategy outlines targeted initiatives for diverse stakeholders to foster gender inclusivity across all aspects of the project in the participating countries. During this reporting period, gender-focused training sessions were conducted in all participating countries, specifically targeting extension workers and farmers (see BTORs 1, 3, 4, FR5). Furthermore, conscious efforts were made to ensure the inclusion of both men and women in all farmer selection processes, capacity-building initiatives, and awareness creation activities. Additionally, farmer training sessions were deliberately held within a 5-kilometre radius of their residences and limited to a maximum duration of four hours. At the decision-making level, the project board demonstrates gender parity with three women members (50%), including a woman serving as the chair.

7. Monitoring and evaluation

While CABI leads the overall Monitoring and Evaluation (M&E) process, ensuring timely delivery of outputs and adherence to the project schedule, it is a collaborative effort involving all partners. During the reporting period, the steering committee and project team convened for one in-person review and planning meeting (refer to Report 6) and held virtual meetings as needed to address

emerging issues. Notably, the project team has reverted to the original logframe submitted at the application stage, as a change request was not addressed (refer to AR2, HYR3). Consequently, the attached logframe reflects this original version.

8. Lessons learnt

Throughout this reporting period, strong collaboration and continuous communication among project partners in Kenya, Uganda, and South Sudan were instrumental in the successful implementation of key project activities. The review meeting served as a valuable platform for reflection, assessment, and strategic planning. Regular bilateral meetings between CABI and individual partner institutions facilitated the timely completion of technical and financial reports and the resolution of emerging issues. Notably, partners demonstrated flexibility in addressing institutional challenges; for example, KEPHIS requested CABI to manage their budget to mitigate potential delays common in public institutions, a similar arrangement that proved effective with NMK, which operated without a signed sub-grant agreement by requesting and accounting for expenditures on their allocated budget line. This collaborative approach in Year 3 was key to the successful implementation of crucial activities across all three countries, particularly in training, site selection, and biodiversity studies

9. Actions taken in response to previous reviews (if applicable)

During the review period, project partners convened a meeting to address various objectives, including donor feedback. Due to unresolved issues regarding the logframe, the team agreed to revert to the original version (clarification provided in the half-year report- see HYR3). The logframe used in this report is the original one that was considered during the project approval. Relevant standard indicators for the project have been identified and reported on. References to relevant documents in the logframe and narrative have been included.

10. Risk Management

Risk register is attached as part of this report

11. Scalability and durability

During this reporting period, the project actively engaged in numerous activities to promote scale-out and long-term sustainability. Capacity strengthening and awareness initiatives targeting crop inspectors, extension workers, farmers, and the general public through diverse channels have effectively sensitized key stakeholders. Following nationwide release approvals in Kenya and Uganda, additional extension officers were trained to support biocontrol efforts, leveraging their government employment for institutionalisation. Farmer engagement was significant, with trained and sensitized via plant health rallies. Interest from farmers in new regions (Baringo and four more counties) after the success in coastal Kenya led to emergency release approval in Baringo and a subsequent nationwide release (see approvals 1-4 and TV broadcasts). In Uganda, farmers demonstrated initiative in supporting parasitoid spread, indicating program value and willingness to participate. Technical materials and products were widely distributed to facilitate PMB biocontrol adoption (refer to BTOR 1-4, report 4- 5), complemented by news articles, blogs, and TV broadcasts for broader engagement. Scientific dissemination included two peer-reviewed publications and three conference presentations in Year 3, enhancing Darwin's visibility. While NEFR establishment was initially explored, the parasitoid's successful establishment and naturalization across release and non-release sites (refer to Reports 1-5, 7, 8) indicates self-sustaining establishment. The dedicated project webpage (https://www.cabi.org/projects/biocontrol-of-papaya-mealybug-in-east-africa/) serves as a central information hub on Darwin and PMB biocontrol work.

Moreover, the technical support and capacity strengthening provided to national institutions in Uganda and Kenya, particularly in laboratory rearing and release procedures, will ensure the sustainability of these efforts beyond the project's duration.

12. Darwin Initiative identity

The Darwin Initiative has received consistent acknowledgement across all project meetings, training sessions, materials, and blogs. A direct link to the Darwin Initiative website is prominently displayed on the project's dedicated page hosted by CABI (https://www.cabi.org/projects/biocontrol-of-papaya-mealybug-in-east-africa/). Furthermore, the Darwin Initiative logo is featured on all project presentations, documents, training manuals, and teaching aids. The project maintains a distinct identity, separate from CABI's broader papaya mealybug initiatives under the PlantwisePlus program. Conscious efforts were made during training to specifically raise awareness about the Darwin Initiative among extension officers and crop inspectors.

13. Safeguarding

14. Project expenditure

Table 1: Project expenditure during the reporting period (1 April 2024 – 31 March 2025)

Project spend (indicative) since last Annual Report	2024/25 Grant (£)	2024/25 Total Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)				
Consultancy costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items (see below)				
Others (see below)				
TOTAL	168,014.36			

Table 2: Project mobilised or matched funding during the reporting period (1 April 2024 – 31 March 2025)

	Secured to date	Expected by end of project	Sources
Matched funding leveraged by the partners to deliver the project (£)			PlantwisePlus
			Standards and Trade Development Facility Managing scale insects in fresh fruits in East Africa Project: to improve cross-border inspection, regulations and practices between Kenya and Uganda
Total additional finance mobilised for new activities occurring outside of the project, building on evidence, best practices and the project (£)			

15. Other comments on progress not covered elsewhere

None

16. OPTIONAL: Outstanding achievements or progress of your project so far (300-400 words maximum). This section may be used for publicity purposes.

I agree for the Biodiversity Challenge Funds to edit and use the following for various promotional purposes (please leave this line in to indicate your agreement to use any material you provide here).

File Type (Image / Video / Graphic)	File Name or File Location	Caption including description, country and credit	Social media accounts and websites to be tagged (leave blank if none)	Consent of subjects received (delete as necessary)
				Yes / No
				Yes / No
				Yes / No
				Yes / No
				Yes / No

Annex 1: Report of progress and achievements against logframe for Financial Year 2024-2025

Project summary	Progress and Achievements April 2024 - March 2025	Actions required/planned for next period
Impact: *Sustainable management of papaya mealybug achieved in East Africa through biological control thereby enhancing livelihoods and protecting native insect biodiversity threatened by pesticide use.*	i. Parasitoid releases in Kenya, Uganda, and South Sudan have established, spread, and significantly reduced PMB populations, leading to decreased pesticide use and increased native insect diversity (see FR1-5; Reports 1-5, 7; Paper 2). ii. Capacity building of government staff and awareness initiatives (rallies, exhibitions, gender-responsive materials) are fostering the adoption and long-term sustainability of these PMB management practices. Over 3067 people trained and sensitised directly, with possibly a larger number reached through TV broadcasts in EA (BTORs, 1-4, 7, 9; Report 4-5; and TV links).	[redacted]
Outcome: East Africa will have an increased regional capacity to manage papaya mealybug using climate-smart biocontrol thereby reducing the risk of native insect biodiversity loss and increasing incomes of farmers		
Outcome indicator 0.1.: The *A. papayae* parasitoid established on at least 75,000 hectares (including women owned farms) by Year 3, determined by post release impact assessment (baseline value 2022 = 0)	• Following approval in additional counties in Kenya and further scale out in Uganda and South Sudan, over 500 farms directly treated with the parasitoid (see FR 1-5, Report 4-5). • Post release monitoring has confirmed establishment in all release and dispersal to over 100 Km from primary release sites (See Reports 4, 5, 8 and BTOR 5).	• None.
Outcome indicator 0.2.: At least 10% increased distribution and abundance, and diversity of native insect biodiversity, particularly natural enemies achieved in the target areas established by biodiversity assessment by Year 3	• Endline biodiversity assessment and post-release monitoring in Kenya and Uganda have confirmed increased diversity of native insect biodiversity particular ladybird beetles species and an important *P. mexicana* parasitoid (See Report 4, 5, 7 and 8).	• None.
Outcome indicator 0.3.: Percent yield loss of papaya associated with papaya mealybug decreased to less than 20% (baseline value 2019 = 57% yield loss) by Year 3	• Farmer testimonials confirm increased yield resulting from the management of PMB (see Report 5, blog). • Socio-economic study to quantify benefits of the PMB CBC underway at time of reporting (see data collection tool -Tool 1).	• None.
Outcome indicator 0.4.: At least 15,000 people (40% women) have better knowledge of classical biocontrol for papaya mealybug, and show novel understanding and skills on conservation biocontrol practices measured through an impact assessment by Year 3	• In Y3 the project has reached over 3,476 individuals with information on classical and conservation biocontrol for PMB, including 106 extension officers (61 M, 45 F - Kenya), 20 crop inspectors (19 M, 1 F - South Sudan), 675 directly trained farmers (313 M, 311 F - Kenya), 2,661 farmers sensitized via rallies (1485 M, 1176 F), 134 participants at the expo (92 M, 42 F), and 51 farmers and extension staff in Uganda (29 M, 22 F) (see BTORs 1- 4, 9; Report 4-5, FR 5). • Over 1000 technical information material (factsheets, PMDGs, Photosheets etc) have been distributed to different stakeholders (see BTOR 2 and 9; Products 1-3) • 29 pieces (blogs, news articles, TV broadcasts) on PMB biocontrol work published to further enhance the reach-	• None

	estimated at 26.1 M (ref to blog, TV links above; media metrics https://cabi.coveragebook.com/b/9f1419b0072ffc41#metrics-summary - Press 1)	
Outcome indicator 0.4: Frequency of use and expenditure on pesticide by smallholder farms associated with papaya mealybug control reduced by at least 50%, particularly among women (baseline 2019 = 51% of smallholder use pesticides, pesticide, use intensity £204 per ha)	• Post-release has confirmed reduction and/or withdrawal of pesticides use in the release sites (see Report 4 & 5). • Socio-economic surveys are underway to quantify benefits of the biocontrol program including pesticides costs and frequency (see data collection too l- Tool 1)	• None
Interim outcome indicator: At least 120,000 *A. papayae* individuals produced and released by Year 1.5 in the three countries (300,000 by Year 3)	• More than 1.5 million parasitoids have been released in the implementing countries. (see release FR 1-5 and Data 1 and Data 3)	• None
Output 1: The *A. papayae* parasitoid released and naturalized in East Africa for the sustainable biological control of papaya mealybug and protection of native insect biodiversity		
Output indicator 1.1: The optimal ecological niche of *A. papayae* to determine suitability and potential release areas for establishment published by Year 1	• Ecological niche modelling for *A. papayae* completed for Africa. Results published in the Biocontrol Journal (see Paper 1).	
Output indicator 1.2: Number and diversity of native insects present at the selected "biological control learning sites" established by Year 1 (baseline) and Year 3 (end of project).	• Endline biodiversity assessment conducted in Kenya and Uganda. Native insect checklists developed (see Report 7- 8, BTOR 5). • This activity was not conducted in South Sudan due to escalating security and political instability (multiple global news).	• None.
Output indicator 1.3: At least 75,000 *A. papayae* individuals released in Kenya, South Sudan, and Uganda by Year 3	• Over 1.5 million parasitoids released in the three countries. (see release FR 1-5; Data 1 and Data 3). • Introduction permits obtained for all the three countries including an emergency release and nationwide field release in Kenya (see Approval 1-4).	• More releases and augmentation in Kenya and Uganda, supported by CABI's PlantwisePlus (PW+) program
Output indicator 1.4: At least 100 (50 women) farmer managed *A. papayae* reservoirs set up on farmers' fields to mass produce *A. papayae* parasitoid for augmentative field releases by Year	• More than 3000 farmers trained on in-situ production. In Y3, NEFRs were deprioritised as the parasitoid demonstrated high establishment rates without the need for NEFRs. However, the trained farmers and extension staff have the required knowledge and skills to support augmentative biocontrol should need arise	• None
Output 2: Capacity of crop inspectors, small-holder farmers, extension providers and the general public enhanced on in situ management of *A. papayae* to support sustainable management of papaya mealybug and biodiversity conservation		
Output indicator 2.1: At least 10 crop inspectors (50% women) trained in identification of papaya mealybug, *A. papayae* parasitoid and have an understanding of the biological control-biodiversity conservation nexus by Year 1	• 20 (19 M: 1 F) crop inspectors trained in South Sudan (FR 5) in Y3. To date, about 59 (13 females) crop inspectors have been trained in the three countries (see AR2, FR 5).	• None

Output indicator 2.2: At least 100 extension workers and community facilitators (50% women) trained on mass rearing of *A. papayae* in the field, to support the process of naturalization by Year 1.5	• In Year 3, approximately 106 extension officers (45 female) in Kenya and 7 extension officers (4 female) in Uganda received training on PMB biocontrol including mass rearing of the parasitoid and in-situ production. (See BTOR 1, 2, 9; Report 5)	• None
Output indicator 2.3: 150 (50 women) farmers trained on *in situ* production of *A. papayae* in their farms by Year 2	• About 624 (311 females) and 51 (22 females) farmers in Kenya and Uganda, respectively, were trained on PMB biocontrol and in-situ production of parasitoid (see BTOR 1- 4, 9, Report 5). • About 2661 (1176) farmers and members of the public were sensitised on PMB biocontrol and biodiversity nexus in Kenya via plant health rallies (see BTOR 2 and 9)	• None
Output 3: Scientific evidence base generated on impacts of classical biological control of *A. papayae* on livelihoods and native insect biodiversity		
Output indicator 3.1: Evidence of impacts of the classical biological control agent on non-target scale insects documented by Year 2.5	• Post-release monitoring has confirmed abundance of native insects including important natural enemies like the ladybird beetles and *P. mexicana* in the release sites (see BTOR 5; Report 7, 8; Paper 2)	• None
Output indicator 3.2: Effect of pesticide use on native insect biodiversity, comparing abandoned and severely infested fields, infested but yielding fields with and without the parasitoid, and fields with farmers pesticide practices and the biodiversity changes documented by Year 3	• This activity wasn't completed due to difficulty in getting the different categories of farms for comparison. However, endline biodiversity surveys in Kenya and Uganda after pesticide withdrawal confirmed an increase in insect biodiversity including important natural enemies of PMB (See BTORs 5; Report 7, 8)	• None
Output indicator 3.3: Evidence of impacts of the classical biological control approach on the population of the papaya mealybug and crop infestation documented by Year 3	• Post release monitoring and farmer testimonial confirmed reduction in PMB population on their farms (See BTORS 5; Report 4- 5)	• None
Output indicator 3.4: Evidence of impacts of *A. papaya*e biological control on yield and incomes of smallholder households (30% women owned) documented by Year 3	• Socio-economic surveys are underway as of the reporting time to quantify these (see data collection tool- Tool 1). Anecdotal farmer reports confirm increase in production due to reduced PMB on farms (see Report 5).	• None
Output indicator 3.5: Evidence on the native insect biodiversity post-release of *A. papayae* documented to determine the positive impacts of the classical biological control programme by Year 2.5	• Endline biodiversity surveys completed in Kenya and Uganda confirming increase in native insect diversity in the learning sites (see BTORs 5; Report 7, 8)	• None
Output 4: Information on classical biocontrol of papaya mealybug and conservation biocontrol approaches to support natural pest regulation and better management of biodiversity packaged and disseminated to increase farmer knowledge and technology adoption		
Output indicator 4.1: At least 3,000 smallholder farmers, extension officers and other stakeholders receive various gender-responsive communication and awareness activities by Year 2.5	• About 3,476 individuals (106 extension officers, 20 crop inspectors, and 675 farmers directly trained, plus 2661 farmers sensitized via rallies and over 5000 participants at the expo exhibition) have been reached with information on classical biocontrol for PMB and conservation biocontrol practices (See BTORs 1- 4, 6, 8; Report 5). • Tailored gender training incorporated in the technical training to support gender integration in PMB biocontrol work.	• None
Output indicator 4.2: At least 10 (media articles, policy brief, impact stories, factsheets, journal articles) information products targeting	• About 29 pieces of press coverage (blogs, news articles, TV, social media engagement etc.) published on PMB biocontrol work in EA in Y3 reaching an estimated audience of 26.1 million	• None on Darwin but awareness creation to be supported by

different stakeholders developed and disseminated by end of the project by Year 1	people (See https://cabi.coveragebook.com/b/9f1419b0072ffc41#metrics-summary – Press 1) • Two journal papers published in open access scientific journals (ref to Papers 1 and 2). • More than 1000 gender-responsive technical materials were distributed to these groups of stakeholders (see BTOR 1-4, 8, Products 1-3).	other in-country programs (PW+)

Annex 2: Project's full current logframe as presented in the application form (unless changes have been agreed)

Project summary	SMART Indicators	Means of verification	Important Assumptions
Impact: Sustainable management of papaya mealybug achieved in East Africa through biological control thereby enhancing livelihoods and protecting native insect biodiversity threatened by pesticide use			
Outcome: East Africa will have an increased regional capacity to manage papaya mealybug using climate-smart biocontrol thereby reducing the risk of native insect biodiversity loss and increasing incomes of farmers	**0.1:** The *A. papayae* parasitoid established on at least 75,000 hectares (including women owned farms) by Year 3, determined by post release impact assessment (baseline value 2022 = 0) **0.2:** At least 10% increased distribution and abundance, and diversity of native insect biodiversity, particularly natural enemies achieved in the target areas established by biodiversity assessment by Year 3 **0.3:** Percent yield loss of papaya associated with papaya mealybug decreased to less than 20% (baseline value 2019 = 57% yield loss) by Year 3 **0.4:** At least 15,000 people (40% women) have better knowledge of classical biocontrol for papaya mealybug and show novel understanding and skills on conservation biocontrol practices measured through an impact assessment by Year 3. **0.5:** Frequency of use and expenditure on pesticide by smallholder farms associated with papaya mealybug control reduced by at least 50%, particularly among women (baseline 2019 = 51% of smallholder use pesticides, pesticide, use intensity £204 per ha)	**0.1a:** Mid-term and end of project survey of papaya farmers to establish presence or absence of the parasitoid **0.1b:** Scientific publication on the spread and establishment of the parasitoid in 3 countries **0.2:** Reports on the inventory of insect diversity and abundance particularly the natural enemies (baseline under farmers current practices, and impact study midterm and project end) **0.3:** Reports and country records on yield, and pesticide use in papaya production **0.4:** Impact assessment report on the household and community benefits of the project. **0.5a**: Farmer reports and Country records on frequency of pesticide use and associated expenditure. **0.5b:** Impact assessment report at end of project	• Crop yield is not negatively impacted by factors outside the scope of the project such as adverse weather conditions, and public health concerns such as Covid-19 restrictions. Covid-19 is being mitigated by increased vaccinations that have relieved lockdowns and cessation of movement. • Farmers are willing to take up the use of classical biological control for papaya mealybug and reduce pesticide use. CABI has completed a baseline study (unpublished) in Kenya that shows that 85% of farmers view the release of a biological control agent to manage PMB positively (11% and 3% held neutral or negative views, respectively), and most farmers (94%) would support a biological control programme for PMB in their community. Farmers expressed own willingness to reducing their chemical pesticides use, monitoring natural enemy and PMB levels at the community level, adopting practices to support natural enemy establishment, taking on lead farmer roles and using their farms as demonstration plots. A stakeholder awareness with KEPHIS at the Counties revealed willingness to adopt biological control. A similar approach will be followed for Uganda and South Sudan
Interim Outcomes:	• At least 45,000 hectares (30% women owned) directly treated with the release of *A. papayae* (250 parasitoids/ha) under sustainable papaya mealybug management by Year 1.5.	• List and country maps of georeferenced farms where *A. papayae* is released and established, produced through post-release assessments	• Farmers and local governments will allow the mapping of their farms for monitoring purposes. The project aims to use a drone for mapping areas treated with the biocontrol agent, and

	• At least 5% percent change in distribution and abundance of native insect biodiversity in areas where *A. papayae* has established compared to the baseline by Year 1.5	• Mid-term M&E report on effect of *A. papayae* on papaya mealybug. • Biodiversity assessment reports every 6 months. • Mid-term M&E report on pesticide use	field releases using drone technology. Permit for flying drones already secured in Kenya. • Farmers are willing to take up the use of classical biological control for papaya mealybug and reduce pesticide use, which will in turn enhance biodiversity. This has been established during a baseline survey for Kenya, and a similar process will be followed in Uganda and South Sudan. We will conduct stakeholder awareness and famer consultation before releases.
Output 1: The A. papayae parasitoid released and naturalized in East Africa for the sustainable biological control of papaya mealybug and protection of native insect biodiversity	**1.1**: The optimal ecological niche of A. papayae to determine suitability and potential release areas for establishment published by Year 1 **1.2:** Number and diversity of native insects present at the selected "biological control learning sites" established by Year 1 (baseline) and Year 3 (end of project) **1.3:** At least 75,000 A. papayae individuals released in Kenya, South Sudan and Uganda by Year 3 1.4: At least 100 (50 women) farmer managed A. papayae reservoirs set up on farmers' fields to mass produce *A. papayae* parasitoid for augmentative field releases by Year 2	**1.1:** One publication on ecological niche modelling to establish suitability and potential release areas for establishment of *A. papayae* **1.2:** Museum collection and baseline report of native insects at the "biological control learning sites" **1.3:** Permits for parasitoid release from the NPPOs of Kenya, South Sudan and Uganda. **1.4:** Records of the number of A. papayae mass produced for release	• Multiple open data sources are available and accessible on parasitoid distribution for ecological modelling. This is being mitigated by CABIs CKAN, established to provide open access datasets and the CGIAR Open and FAIR Data Assets Policy that took effect from 16 April 2021 ensures access to distribution datasets. • Permits for release of the parasitoid are obtained in a timely manner from the government agencies in charge. Kenya has already issued a permit to release the parasitoid in the country. Similar outcome expected from South Sudan and Ugandan competent authorities following regional protocols.

Output 2: Capacity of crop inspectors, small-holder farmers, extension providers and the general public enhanced on in situ management of A. papayae on sustainable management of papaya mealybug and biodiversity conservation	**2.1:** At least 10 crop inspectors (50% women) trained in identification of papaya mealybug, A. papayae parasitoid and have an understanding of the biological control-biodiversity conservation nexus by Year 1 **2.2:** At least 100 extension workers and community facilitators (50% women) trained on mass rearing of A. papayae in the field, to support the process of naturalization by Year 1.5 **2.3**: 150 (50 women) farmers trained on in situ production of A. papayae in their farms by Year 2	**2.1.1:** Training report on capacity building for crop inspectors and extension workers on papaya mealybug management and biodiversity conservation. **2.2.1:** Training report on capacity building for extension workers and community facilitators on parasitoid mass rearing, and attendance lists **2.3.1**: Report of farmers trained on in situ production of *A. papayae* and attendance lists 2.3.2: Records of the number of *A. papayae* reservoirs set up on farmers' fields at in Kenya, South Sudan and Uganda	• Equipment for setting up field reservoirs at farmers' fields is readily available. Majority of the materials needed are locally available in Kenya and Uganda. Through regional collaboration, South Sudan will be supported by partners to reach the desired scale. • Covid-19 does not persist to restrict gatherings necessary to conduct practical in-person farmer trainings. Covid-19 is being mitigated by increased vaccinations. At regional trainings, only vaccinated persons will be invited to travel and attend.
Output 3: Scientific evidence base generated on impacts of classical biological control of *A. papayae* on livelihoods and native insect biodiversity	**3.1:** Evidence of impacts of the classical biological control agent on non-target scale insects documented by Year 2.5 **3.2:** Effect of pesticide use on native insect biodiversity, comparing abandoned and severely infested fields, infested but yielding fields with and without the parasitoid, and fields with farmers pesticide practices and the biodiversity changes documented by Year 3. **3.3**: Evidence of impacts of the classical biological control approach on the population of the papaya mealybug and crop infestation documented by Year 3. **3.4:** Evidence of impacts of *A. papayae* biological control on yield and incomes of smallholder households (30% women owned) documented by Year 3 **3.5:** Evidence on the native insect biodiversity post-release of *A. papayae* documented to determine the positive impacts of the classical biological control programme by Year 2.5	**3.1.1:** Scientific publication on the impacts of the parasitoid on non-target scale insects and other native beneficial insects **3.2.1:** Scientific publication on the effect of pesticide use on native insect biodiversity under different productivity systems **3.3.1:** Scientific publication on the post-release impact of the classical biological control programme on PMB infestation **3.4.1**: Scientific publication on the socio-economic impact of the parasitoid release on yield, pesticide use and income (both papaya and other insect pollinated crops **3.5.1**: Baseline and final report and maps showing distribution and abundance of native insect species in papaya agro-ecologies **3.5.2:** Museum collections of native insect species from the release sites in space and time	• Smallholder farmers and extension workers are willing to participate in the surveys. As part of the project, CABI will work with the local Governments to secure prior informed consent at the farmer level before any parasitoids are released on their farms. Stakeholder awareness meetings will be conducted at the release sites prior to implementation of activities. A baseline study at the beginning of the project will document the native insect biodiversity in farmer managed papaya field versus field with the parasitoid periodically to track biodiversity changes.

Output 4. Information on classical biocontrol of papaya mealybug and conservation biocontrol approaches to support natural pest regulation and better management of biodiversity packaged and disseminated to increase farmer knowledge and technology adoption	**4.1:** At least 3,000 smallholder farmers, extension officers and other stakeholders receive various gender-responsive communication and awareness activities by Year 2.5 **4.2:** At least 10 (media articles, policy brief, impact stories, fact sheets, journal articles) information products targeting different stakeholders developed and disseminated by end of the project by Year 1	**4.1.1:** Manual documenting the best practices of pest control and biodiversity conservation **4.1.2:** Report on awareness activities (title, content, audience) **4.2.1:** Blogs, social media articles, Publications, radio programmes, fact sheets, photo sheets, pamphlets, brochures; project progress and final reports; feedback from stakeholders in the final report.	• National stakeholders are willing to collaborate in providing information. Information will be obtained by in-person communication planning meetings with stakeholders. • Political and public health concerns such as Covid-19 are suitable for holding mass awareness activities. Covid-19 is being mitigated by increased vaccinations.

Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)

1.1: Conduct ecological niche modelling to evaluate the environmental suitability for *A. papayae* across East Africa to identify potential release areas, Y1 Q3

1.2: Undertake a baseline study at selected biological control learning sites to determine the native insect biodiversity under farmers practices, Y1, Q3

1.3: Conduct area-wide releases of *A. papayae* in Kenya, South Sudan and Uganda using hand releases and also deploying technology such as drones and landscape scale, Y3 Q3

1.4: Establish *A. papayae* reservoirs on farmers' fields for parasitoid mass production in situ for augmentative field releases during naturalization, Y1 Q3; Y2 Q2 and Y3 Q3

1.5: Conduct monitoring to determine post-release establishment and parasitoid efficacy as well as expansion outside the release areas, Y1 Q3; Y2 Q2; Y3 Q1, Y4 Q4

2.1: Train crop inspectors in identification of papaya mealybug and related scale insects, the *A. papayae* parasitoid and the biological control-biodiversity conservation nexus, Y1 Q2; Y2 Q1; Y3 Q4

2.2: Train extension workers and community facilitators on conservation of *A. papayae* in the field, to support the process of naturalization, Y1 Q3; Y2 Q2, Y3 Q1, Y4 Q3

2.3: Train farmers on in situ production of A. papayae in their farms, Y3 Q3

3.1: Undertake surveys to establish the effect of pesticide use on native insect biodiversity, comparing fields with and without the parasitoid, and fields with farmers pesticide practices, Y1 Q1; Y1 Q3; Y2 Q1; Y2 Q3; Y3 Q1; Y3 Q3

3.2: Conduct socio-economic studies to determine the impacts of the CBC approach on the population of papaya mealybug and crop infestation, Y3 Q3

3.3: Undertake surveys to assess the impacts of *A. papayae* biological control on yield and incomes of smallholder households, Y3 Q3

3.4: Generate an inventory of native insect biodiversity pre-and post-release of A. papayae to determine the positive impacts of the classical biological control programme on insect biodiversity; Y1 Q1; Y1 Q4; Y2 Q3; Y3 Q2

3.5: Conduct surveys to establish impacts of the classical biological control agent on non-target scale insects, Y3 Q3

4.1: Develop an effective, gender responsive communication plan, integrating multi-channel communication approaches appropriate for reaching men and women smallholder farmers, Y1 Q3

4.2: Produce and disseminate different information products on targeting different stakeholders on dual purpose - pest control and biodiversity conservation nexus, Y4 Q4

Checklist for submission

	Check
Different reporting templates have different questions, and it is important you use the correct one. Have you checked you have used the **correct template** (checking fund, scheme, type of report (i.e. Annual or Final), and year) and **deleted the blue guidance text** before submission?	Y
Is the report less than 10MB? If so, please email to BCF-Reports@niras.com putting the project number in the Subject line.	Y
Is your report more than 10MB? If so, please consider the best way to submit. One zipped file, or a download option, is recommended. We can work with most online options and will be in touch if we have a problem accessing material. If unsure, please discuss with BCF-Reports@niras.com about the best way to deliver the report, putting the project number in the Subject line.	Y
Have you included means of verification? You should not submit every project document, but the main outputs and a selection of the others would strengthen the report.	Y
Have you provided an updated risk register? If you have an existing risk register you should provide an updated version alongside your report. If your project was funded prior to this being a requirement, you are encouraged to develop a risk register.	Y
If you are submitting photos for publicity purposes, do these meet the outlined requirements (see Section 16)?	N
Have you involved your partners in preparation of the report and named the main contributors	Y
Have you completed the Project Expenditure table fully?	Y
Do not include claim forms or other communications with this report.	