Darwin Initiative
Final Report

*To be completed with reference to the Reporting Guidance Notes for Project Leaders (http://darwin.defra.gov.uk/resources/) it is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin project information

Project reference	21-005
Project title	Pesticide plants for organic cotton, livelihoods and biodiversity in Mali
Host country(ies)	Mali
Contract holder institution	RBG, Kew
Partner institution(s)	Institut d'Economie Rurale (Mali); FENABE (Mali); Département de la Médecine Traditionnelle (Mali); Eaux et Forêts (Mali); Natural Resources Institute (UK)
Darwin grant value	£258, 540
Start/end dates of project	01/04/2014-30/09/2017 (with 6-month no-cost extension agreed by DEFRA and 2-month extension on final report submission)
Project leader's name	Dr. Paul Wilkin, Head of Natural Capital & Plant Health Department
Project website/blog/Twitter	https://www.kew.org/science/projects/pesticide-plants-for-organic-cotton-in-mali
Report author(s) and date	Paul Wilkin, Paolo Ceci, Stéphane Rivière, Sidi Sanogo. 28/02/2018

1 Project Rationale

Mali is a Least Developed Country facing increasing pressure on its natural resources and biodiversity. In the regions of Sikasso, Segou, Kayes and Koulikoro, communities rely on cotton as one of the important cash-crops. However, Mali's 4th CBD Progress Report highlighted that increased cotton cultivation is threatening ecosystems because of the harmful chemical pesticides used and the depletion of forest cover.

At the point of project design, it was clear that the growing organic cotton market provided an opportunity for farmers in Mali to double their income in comparison to the sale of conventional cotton, while reducing their impact on the environment. However, production of organic cotton relied on unsustainable wild harvesting of naturally pesticidal plants to replace chemical pesticides.

A number of pesticide-producing plant species were in decline, threatening the long-term viability of organic cotton production. Kew led consultations with farmers which showed that there was a "trial and error" approach to using native pesticide plants, with a limited understanding of the volume or dilutions needed to protect crops. This caused waste and

affected the reliability and efficacy of these natural pesticides. There was also no knowledge of how to collect, conserve, germinate and propagate seeds from these species to ensure sustainable supplies. If these issues were not addressed, wild plant populations would diminish or even become extinct, threatening livelihoods, the resilience of communities and biodiversity.

This project aimed to increase the income of target communities in Mali and reduce the depletion of plant biodiversity by providing the scientific expertise needed to establish the sustainable use and cultivation of native pesticide plants for organic cotton production.

Activities fall under the following six areas:

1. Identification and authentication of native pesticide species currently used by organic cotton farmers in target communities
2. Active compounds/ingredients in the key pesticide plants being used by cotton producers are identified
3. Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers
4. Four community demonstration gardens established to strengthen the capacity of target communities to cultivate pesticide plants.
5. Increased awareness of pesticide plant use for organic cotton production among policy makers in Mali (CMDT, Department of Agriculture, Department of Forestry).
6. Assessment of potential climate risks that may impact on pesticidal species.

Project activities took place in four regions of southwestern Mali: Kayes, Koulikoro (surrounding Bamako Capital District), Sikasso and Segou (see map below). IER's Forestry Research Programme is based in Sikasso and FENABE in Bougouni.

Project duration has been extended by six months and the deadline for final report submission by two months, i.e. end of February 2018, in order to capture activities still going on in December 2017.

2 Project Partnerships

The principal project partner in Mali is IER (*Institut d'Economie Rurale*), the national agricultural research institution, which hosts the Forestry Research Programme located at the Regional Centre of Sikasso. IER has worked with Kew to study the diversity of and conserve the Malian flora for over 15 years and has the expertise to undertake wild seed collecting, handling and conservation as well as establishing community gardens. Kew and IER have worked closely together to strengthen the capacity of the institutions in Mali to manage the country's flora. This collaboration has led to an active national seed bank, herbarium and comprehensive database of about 50% of Mali's wild plant species held at IER, and provided the base upon which the present project built upon. The lead contact in IER is Dr. Sidi Sanogo who is a seed expert and the national manager of Mali's seed bank. His principal responsibilities are project implementation and coordination, reporting, project management and community participatory M&E.

The former PI in RBG Kew, Dr. Moctar Sacande, left the organisation after Y1, posing a major challenge to smooth project management and implementation. He was replaced by Dr. Paul Wilkin from Y2 onwards. Activity in Mali has been entirely under the management of IER with progress reported to RBG Kew. Direct participation in field work by Kew staff has not been possible due to security issues linked to terrorist threat in Mali.

A project partnership with *Mouvement Biologique Malien* (MOBIOM) was managed through IER. It was underpinned by an agreement established in Y1 defining the activities that would be carried out every year by each partner. In Y3, MOBIOM was replaced in the project partnership by another association of producers' cooperatives, FENABE "*Fédération Nationale de Producteurs de l'Agriculture Biologique et Équitable du Mali*".

The partnership with the Natural Resources Institute (NRI), University of Greenwich, was underpinned by Prof. Phil Stevenson's joint appointment at RBG Kew and NRI and provided scientific evidence to the validation of plant-based pesticides via bio-assays and chemical analysis using the facilities of both organisations. Prof. Stevenson and his team at RBG Kew have played a more important role in the project than initially envisaged since the departure of the previous PI. His role in NRI has been also instrumental to planning the workshop in Tamale held in Y3. During Y2 and Y3 the partnership has been consolidated between IER and DMT (*Département de Médecine Traditionnelle de l'Université de Bamako*). Prof. Rokia Sanogo from DMT has undertaken toxicity tests in pesticidal plants and investigated their phytochemical composition in addition to work done by Prof. Stevenson's team. Collaboration between DMT and RBG Kew had already started in the framework of the Useful Plants Project (PI: Dr. Tiziana Ulian).

The main coordination and communication channel has between RBG Kew and IER Mali. Dr. Sidi Sanogo travelled three times to RBG Kew, Wakehurst Place, in Y3 and during the 6-month extension to work directly with Kew staff. IER submitted to RBG Kew regular progress report every six months and held meetings with FENABE every three months. Occasional meetings were organised by IER with DMT as needed. DMT and FENABE shared their activity reports with IER. Each organisation involved at the country level followed its own management procedures and functioning. The institutional partner in the field was *Eaux et Forêts* (Bougouni and National Directorates of Forestry Department), charged with support to plant production, training to nurserymen, supervision of field work and monitoring of experimental parcels. Additional country stakeholders involved in dissemination of project results and mainstreaming at policy level were: *Compagnie Malienne pour le Développement du Textile* (CMDT), Agriculture Department (National and Bougouni Directorates), *Chambre d'Agriculture* of Bougouni and the NGO HELVETAS.

The present report has been coordinated and edited by Dr. Paolo Ceci (Africa Projects Coordinator), with support from Dr. Paul Wilkin, Dr. Tiziana Ulian and Dr. Sidi Sanogo.

3 Project Achievements

The latest project logframe, which was agreed upon in December 2016 following the Mid-Term Review, is presented in Annex 1, while Annex 2 summarizes progress against it.

3.1 Outputs

Progress towards project outputs

Output 1:	Identification and authentication of pesticide species currently used by organic cotton farmers in target communities.		
	Baseline	Change recorded by 2017	Source of evidence
Indicator 1.1 Established base list of pesticide species collated from desk study and questionnaires addressed to organic cotton farmers in the four regions of Mali.	No list of pesticide plants at project start.	Base list of 26 species established from desk study and questionnaires administered in the regions of Sikasso, Ségou, Koulikoro and Kayes.	Socio-economic/ethno-botanical survey report (Annex 7), database (Annex 8 for a screenshot).
Indicator 1.2 Collections of specimens of seeds and herbarium vouchers of pesticide species.	No specimens of seeds and herbarium vouchers of pesticide plants at project start.	104 voucher specimens of 65 pesticide/multi-purpose species and 45 seed accessions stored in Mali during project implementation. Collection of 416,000 seeds of *Nicotiana tabacum* and relevant specimen voucher sent to Kew in 2014 and stored in the MSB. Plant samples of *Carapa procera, Chamaecrista nigricans, Khaya senegalensis, Securidaca longipedunculata, Bobgunnia madagascariensis*, *Balanites aegyptiaca* and *Cassia sieberiana* sent to Kew in Y1 and Y2 for bio-assays. Collections of seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea,*	IER herbarium and seed bank, SID database, IER seed delivery note (Annex 9), germination report (Annex 17, 17a), IER six-month reports (available on request).

		Azadirachta indica and Lannea microcarapa sent to Kew in 2017 for germination tests.	
Indicator 1.3 List of pesticidal species that have been authenticated in the field and laboratory, with confirmed scientific and vernacular names.	No list of authenticated pesticide species at project start.	List of 34 pesticide species authenticated and scientific and vernacular names confirmed plus data from bio-assays and field experiments collected.	Socio-economic/ethno-botanical survey report (Annex 7), database (Annex 8 for a screenshot), bio-assay reports (Annex 10)

Output 2:	Active compounds/ingredients in the key pesticidal plants being used by cotton producers are identified and relative effectiveness of different species established.		
	Baseline	Change recorded by 2017	Source of evidence
Indicator 2.1 Identification of chemical composition of the key pesticide species.	No identified components at project start	Components not identified at Kew due to crash in *Helicoverpa armigera* colony. Classes of compounds in six species were identified by DMT in Mali. DMT reports examine content of insecticidal active ingredients (mg and %) in extracts of pesticidal plants.	DMT reports (Annex 11)
Indicator 2.2 Establish pesticidal efficacy of at least six species in laboratory conditions.	No knowledge of relative effectiveness of different species at project start.	Relative effectiveness assessed via bio-assays in seven species at Kew.	Bio-assay reports (Annex 10)
Indicator 2.3 Determine dose of combined ingredients of different species in field trials.	Known dosages of grains of Azadirachta indica and oil of Carapa procera (farmers' formulation).	in Mali, 20 ml/kg dosage was tested of *Balanites aegyptiaca* seed oil and 20% extemporaneous solutions of *Chamaechrista nigricans* leaves, *Carapa procera* leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*. It showed no toxic effects after 14 days from the treatment. Dosage of 20 ml/kg of *Carapa procera* oil led to the death of one of the three mice used for the test after 24 hours. Field data were generated on two new formulations.	DMT reports (Annex 11), trial plot report (Annex 12), socio-economic/ethno-botanical survey report (Annex 7).

		Seed cotton yield in 2017 in Kolondiéba was 649,60 kg/ha with one of the new formulations and 524,60 kg/ha with the old one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the old one.	

Output 3:	Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers.		
	Baseline	Change recorded by 2017	Source of evidence
Indicator 3.1 Ten farmers from the four regions and FENABE technical team trained in producing optimum standard plant-based products for organic crop production.	No farmers/small scale producers trained at project start.	Two training workshops were held in Y2. Two facilitators from MOBIOM, which then became FENABE, attended with 10 and 14 women respectively (cooperative secretaries) who disseminated knowledge back to cooperative members. Two village facilitators in Ifola were trained in *Balanites aegyptiaca* oil extraction techniques. Women in Ziekorodougou were trained in *Carapa procera* oil extraction techniques. In the second half of Y3, a training workshop was held in Tamale, Ghana (security reasons). It was organised in close collaboration with FENABE and was attended by representatives from five farmers' cooperatives in Yanfolila, Madina-Bougouni, Bla, Boyi-Kolondièba and Samguela-Yanfolila. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. After Tamale, three restitution workshops were organised in Niala, Yanfolila and Madina-Diawara. A workshop was held in Bougouni on 9-10 Jan 2018 to validate FENABE/IER studies on harvest and production sites of bio-pesticides, on farmers'	Tamale workshop report (Annex 13), Tamale training material (Annex 14), restitution workshop report (Annex 15), new formulation workshop report (Annex 16), germination report (Annex 17, 17a), FENABE reports (Annex 18), IER/FENABE report on climate change impacts (Annex 20), IER six-month reports (available on request).

		practices and knowledge on bio-pesticides, and on potential climate change impacts on pesticidal plants. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni et Yanfolila. They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). They were organised by FENABE and animated by IER, thanks to TRAID matching fund, and gathered 125 participants from Yorosso, Bla, Bougouni, Kita and Yanfolila. A desk study was conducted at Kew on seed storage, dormancy and germination of key pesticidal plants. Germination tests were run in 2017 at Kew on seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa.* Results were disseminated and relevant leaflets were produced in French during the extension phase of Y3.	
Indicator 3.2 Small-scale supply branches of standardised pesticide products set up in each of the four regions managed by the trained farmers as inputs.	No small-scale supply branches of standardised pesticide products at project start	Two cooperatives (Samaguéla and Ziékorodougou) were equipped for *Carapa procera* oil production. A system of production/supply was established by individuals using facilities for oil extraction. FENABE conducted a study on harvest and production sites of bio-pesticides, which was validated at a workshop held in Bougouni on 9-10 Jan 2018.	FENABE reports (Annex 18), IER six-month reports (available on requests).
Indicator 3.3 Specific market niche of pesticidal plant products identified and	No market niche for plant products at project start.	Niche market established through *Azadirachta indica extract and Carapa procera* oil production sale.	FENABE reports (Annex 18), IER six-month reports (available on

investments established.		Assessment conducted by FENABE on broader commercial potential for optimum standard organic pesticides and validated at a workshop held in Bougouni on 9-10 Jan 2018.	requests).

Output 4:	Four community demonstration gardens established to strengthen the capacity of target communities to cultivate pesticidal plants. This will provide an alternative to wild plant harvesting and ensure sustainable supplies of key plants in the future.		
	Baseline	Change recorded by 2017	Source of evidence
Indicator 4.1 Maintenance of demonstration gardens of at least 1 ha in each of the four regions, planted with key pesticide species seedlings.	No demonstration gardens at project start.	Four community gardens established, replenished, monitored and maintained. A total of seven species were planted in 25,5 ha in Bougouni, Yanfolila, Bla and Kolondiéba across 38 farms for a total of 10,200 plants (density 5 m by 5 m). Species planted were *Adansonia digitata, Carapa procera, Faidherbia albida, Khaya senegalensis, Parkia biglobosa, Tamarindus indica and Ziziphus mauritiana.* Seedlings used for replenishment were around 5,000. *Ziziphus mauritiana* was planted only in Bla and was not maintained after Y1. Data on survival and growth rate were generated via bio-physical evaluations in Y2 and Y3 and are available.	Bio-physical evaluation report (Annex 19), IER six-month reports (available on requests).
Indicator 4.2 Seed supply and increased seedling production of pesticide species in nurseries to ensure individual needs and continuity of cultivation.	Limited seed collection and seedling production at project start.	Five village nurseries of approximately 0.5 ha each were established to produce seven pesticide species and seedlings produced were planted. A total of 34,430 seedlings were distributed for the demonstration plots and members of organic cotton producers' cooperatives in the four regions.	Bio-physical evaluation report (Annex 19), IER six-month reports (available on requests).
Indicator 4.3 Assessing and annually collecting data on survival and growth of seedlings in the plots.	No relevant data available at project start.	Data on survival and growth rate were generated via bio-physical evaluations of 10,200 pesticide plants.	Bio-physical evaluation report (Annex 19), IER six-month reports (available on requests).

Output 5:	Reference materials produced for the identification of pesticidal plants in Mali, their relative effectiveness, and their optimal and efficient use in organic cotton production.			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 5.1 CMDT/Agriculture/Forestry use project guidelines for managing native pesticidal plants.	Limited awareness of best practices for managing pesticidal plants.	The 2014/2015 campaign results were presented to farmer cooperatives. Results of subsequent campaigns were presented to the Departments of Agriculture and Forestry and to CMDT at national planning workshops. A two-day workshop was held in Tamale, Ghana, on 8-9 June 2017. It focused on scientific knowledge concerning cultivation of pesticidal plants and on raising awareness of their benefits among policy makers. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. After Tamale, three restitution workshops were organised in Niala, Yanfolila and Madina-Diawara. These events were attended by the national institutions involved, including the *Chambre d'Agriculture*, and relevant reports were shared. CMDT did not attend the workshop in Tamale due to a resource issue. A workshop was held in Bougouni on 9-10 Jan 2018 to validate FENABE/IER studies on harvest and production sites of bio-pesticides, on farmers' practices and knowledge on bio-pesticides, and on potential climate change impacts on pesticidal plants. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni and Yanfolila. They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). They were organised by FENABE	Tamale workshop report (Annex 13), Tamale training material (Annex 14), restitution workshop report (Annex 15), new formulation workshop report (Annex 16), germination report (Annex 17, 17a), FENABE reports (Annex 18), IER/FENABE report on climate change impacts (Annex 20), IER six-month reports (available on request).	It is still too early to witness a full-fledged outcome.

		and animated by IER, thanks to TRAID matching fund, and gathered 125 participants from Yorosso, Bla, Bougouni, Kita and Yanfolila. A desk study was conducted at Kew on seed dormancy and germination of key pesticidal plants. Germination tests were run in 2017 at Kew on seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa.* Results were disseminated and relevant leaflets were produced in French during the extension phase of Y3.		
Indicator 5.2 Dept. of Agriculture and Forestry recognise the importance of local useful trees/plants and work on reversing farming practices' focus on land clearing before planting crops.	Community garden approach not mainstreamed.	*Eaux et Forets* (Dept. of Forestry) are intermediary IER partners at field level and contribute to disseminating the community garden approach.	IER web page on sound sowing practices, IER six-month reports (available on requests).	This activity aimed to help implement the National Forest Code (1999).
Indicator 5.3 CMDT/Agriculture/Forestry integrate the ecological resilience of farming system in rural communities' development via project final workshop in West-Africa, where	Ecological resilience of farming systems not mainstreamed.	A two-day workshop was held in Ghana in 2017, followed by restitution workshops in Mali. Training workshops on biological pesticides were held in 2018 (see Indicator 5.1). CMDT and the targeted State Departments started discussions with stakeholders such as HELVETAS.	Tamale workshop report (Annex 13), Tamale training material (Annex 14), Restitution workshop report (Annex 15), new formulation workshop report (Annex 16).	

Forestry agents would promote the project methodology .				

Output 6:	Analysis of climatic data and climate change mitigation plan.		
	Baseline	Change recorded by 2017	Source of evidence
Indicator 6.1 Assessment of potential climate risks that may impact on pesticidal species.	No analysis of climate data and climate change mitigation plan at project start.	Response of key pesticide species to climate change assessed through surveying farmers' experience in the areas of Bougouni, Bla, Yanfolila, Yorosso and Kita. Risks highlighted of diminished seed production, decreased density and mortality. Three species emerged for their potential to adapt: *Azadirachta indica*, *Khaya senegalensis* and *Securidaca longipedunculata*. The assessment was validated at a workshop held in Bougouni on 9-10 Jan 2018.	IER/FENABE report on climate change impact on pesticidal plants (Annex 20).

3.2 Outcome

Progress towards the project Outcome

Outcome:	The sustainable use and cultivation of pesticide plants for organic cotton production leads to increased income generation among target communities and reduces the loss of plant biodiversity in Southern Mali.		
	Baseline	Change by 2017	Source of evidence
Indicator 1 Native pesticidal plants successfully established in community demonstration gardens as farmer field schools in each of the regions by Y3.	6.5 ha planted in Y1.	Four community gardens established, replenished, monitored and maintained. A total of seven species were planted in 25,5 ha in Bougouni, Yanfolila, Bla and Kolondiéba across 38 farms for a total of 10,200 plants (density 5 m by 5 m). Seedlings used for replenishment were around 5,000. *Ziziphus mauritiana* was planted only in Bla and was not maintained after Y1. Data on survival and growth rate were generated via bio-physical evaluations in Y2 and Y3 and	Bio-physical evaluation report (Annex 19), IER six-month reports (available on request).

		are available. Five village nurseries of approximately 0.5 ha each were established to produce seven native pesticide species and seedlings produced were planted. A total of 34,430 seedlings were distributed for the demonstration plots and members of organic cotton producers' cooperatives in the four regions.	
Indicator 2 Important pesticide species show marked reduction in losses, benefitting the conservation of wild populations.	Y1 vegetation survey did not take place due to a failure of management by the previous PI. Nevertheless, a socio-economic/ethno-botanical survey was implemented in 2015 and repeated in 2017, and captured the information needed to assess Indicator 2. In 2015, 40% of the surveyed farmers harvested pesticide plants from the wild. The number of core species used to produce bio-pesticides and potentially harvested from the wild was ten.	In 2017, 15% of the surveyed farmers harvested pesticide plants from the wild. The number of core species used to produce standardised bio-pesticides and potentially harvested from the wild was five. These data show a change in behaviour and by assumption a reduction in losses of important pesticide species.	Annex 7 (spreadsheets 2015 and 2017)
Indicator 3 Yields of 'first class' organic cotton increase by 5% across target communities, increasing farmers' revenues and securing crop bonuses for reaching organic cotton production targets by Y3.	Data were generated through trial plots on two new bio-pesticide formulations. Organic cotton yield in 2015 in Kolondiéba was 607,40 kg/ha with the new formulation and 475,00 kg/ha with the old one. In Yanfolila, the organic cotton yield was 699,60 kg/ha with the new formulation and 549,60 kg/ha with the old one.	Organic cotton yield in 2017 in Kolondiéba was 649,60 kg/ha with the new formulation and 524,60 kg/ha with the old one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the old one. Yet, data varied substantially across observation years and no significant information can be extracted from trial plots. The socio-economic/ethno-botanical survey revealed that average yield of organic cotton in 2017 was 925 kg/ha in the regions of Sikasso, Ségou and Kayes, showing a decrease of	Annex 7, Annex 12, Annex 21

	The socio-economic/ethno-botanical survey revealed that average yield of organic cotton in 2015 was 1059 kg/ha in the regions of Sikasso, Ségou and Kayes. This information does not seem to be reliable (overestimation) when compared to yields from trial plots. Average area cultivated to organic cotton was 0,7 ha. Average area cultivated to conventional cotton was 3,3 ha. According to HELVETAS, average yield of organic cotton in 2015 was 435 kg/ha in the areas of concern of FENABE.	13%. This information does not seem to be reliable (overestimation) when compared to yields from trial plots; however, the decrease could be partly explained by a reduction of average area cultivated to organic cotton (from 0,7 ha to 0,6 ha) or attributed to external factors, such as erratic rainfall. Yet, the target established by Indicator 3 was not met. Interesting to note that also average area cultivated to conventional cotton has decreased from 3,3 ha to 2,6 ha. According to HELVETAS, average yield of organic cotton in 2017 was 455 kg/ha in the areas of concern of FENABE. Nonetheless, this information was not produced within the project.	
Indicator 4 All beneficiary women farmers (20% of FENABE) have increased their income by 10 to 25% in the four regions by Y3. All direct beneficiary men farmers have increased their income by 10 to 25% in the four regions by Y3.	The socio-economic/ethno-botanical survey carried out in 2015 had only seven women farmers in the sample, the number is too small to assess Indicator 4. Average sale price for organic cotton was CFA 300/kg and CFA 235/kg for conventional cotton. FENABE did not provide figures related to women and men farmers' income.	The socio-economic/ethno-botanical survey repeated in 2017 had only seven women farmers in the sample, the number is too small to assess Indicator 4. Increase in income of men farmers is difficult to prove as overall production of organic cotton seems to have decreased. In 2017, average sale price for organic cotton was CFA 300/kg and CFA 250/kg for conventional cotton. If women or men farmers increased their income it is unlikely due to on-farm organic cotton production. FENABE did not provide specific figures related to women and men farmers' income.	Annex 7
Indicator 5 >25% of cotton farmers in target communities use optimum standard	The socio-economic/ethno-botanical survey carried out in 2015 revealed that 94% of	The socio-economic/ethno-botanical survey repeated in 2017 revealed that 94% of the sample farmers used bio-pesticides.	Annex 7 (spreadsheets 2015 and 2017)

organic pesticide and treatment regimes, reducing wastage by Y3	the sample farmers used bio-pesticides. Farmers using only bio-pesticides were 35%, 4% used only chemical pesticides and 60% used both.	Farmers using only bio-pesticides were 40%, 28% used only chemical pesticides and 30% used both. Data are inconsistent and do not allow to understand if farmers using bio-pesticides were actually 94% or 70%. Though the target established by Indicator 5 is met, there is no indication that this is a result of the project. On the contrary, the use of chemical pesticides has increased, alerting about pressing climate change impacts.	

3.3 Impact: achievement of positive impact on biodiversity and poverty alleviation

Impact statement from logframe: The sustainable use and cultivation of useful native plants support biodiversity conservation and poverty reduction in rural Mali.

The impact statement can only be partly claimed as achieved. Although the sustainable use and cultivation of useful native plants seems to support biodiversity conservation, this assumption could only be verified through proxy data (number of farmers harvesting pesticidal plants from the wild and number of core plant species used to produce standardised bio-pesticides). Data on direct indicators to measure project contribution to biodiversity conservation are not available, as the planned vegetation survey did not take place in Y1 due to management failure of the former PI. The second assumption in the impact statement, i.e. the sustainable use and cultivation of useful native plants support poverty reduction in rural Mali, was not found to be obvious, at least according to what could be captured from the small farmers' sample surveyed in 2015 (68) and 2017 (65). The project was very prolific in terms of training, capacity development and propagation of pesticide plant species in the field, but it appears that establishing appropriate systems to measure outcome indicators and targets achieved was a lesser concern. Anyhow, from the data available no steady organic cotton production increase can be observed, having the average production decreased from 1059 kg/ha in 2015 to 925 kg/ha in 2017 in the farms surveyed in the regions of Sikasso, Ségou and Kayes. This information must be taken with caution, as yield data do not seem to be reliable (overestimation) as compared to those from the trial plots. No increased income from on-farm organic cotton production can be assumed either, as the average sale price remained constant from 2015 to 2017 (CFA 300/kg). Instead, the increased sale price of conventional cotton (from CFA 235 to CFA 250) and enhanced use of chemical pesticides make us reflect on the opportunity that farmers may adopt different livelihood strategies in future as they are likely struggling to face market drivers and climate change impacts, such as erratic rainfall and pest outbreaks. Gender disaggregated data are not sufficiently available to assess project contribution to the well-being of all women members of FENABE (4,164 or 20% of the total 20,820 FENABE members).

An improved yield of organic cotton was observed in trial plots in 2015 and 2017 using project-promoted bio-pesticide formulation as compared to the old farmers' formulation. Nevertheless, as shown in the table below, yield data from trial plots varied substantially over years and cannot be considered as conclusive.

Year	Organic cotton yield (Kg/ha) and variance coefficient (%)			
	Kolondiéba		Yanfolila	
	Farmers' formulation	New formulation	Farmers' formulation	New Formulation
2015	475,00 (40%)	607,40 (54%)	549,60 (40%)	699,60 (27%)
2016	726,00 (18%)	921,50 (14%)	522,20 (19%)	658,40 (12%)
2017	524,60 (40%)	649,60 (38%)	599,60 (54%)	612,20 (53%)

Bio-assay results were not significant and additional research on the chemical constituents and effectiveness of pesticide plant extracts is needed to substantiate farmers' traditional knowledge.
Germination experiments were carried out for pesticide species whose germination had not been studied and documented before and integrated a literature and database review on storage, dormancy and germination of pesticide species seeds. Scientific information on germination is very important to develop sound propagation protocols and supports partners and farmers in cultivating and conserving multi-purpose plants *in-situ*. Project achievements are remarkable in relation to plant propagation in communities and demonstration parcels, training and capacity building for research on conservation and sustainable use of pesticidal plants.
The attempt made by the project to link communities' traditional knowledge, research world, institutions, field practitioners and revenue opportunities is also commendable and strengthened a promising partnership between RBG Kew, IER, DMT, *Eaux et Forêts* and FENABE. The experience emphasized the role that science may play in advising thousands of farmers on the adoption of sustainable practices.
The nature of the project partnership allowed to deploy a strong participatory approach to working with communities. Although the smooth implementation of the initiative was hampered by management issues (departure of the former PI) and by impossibility for international staff to travel to Mali due to security reasons, it achieved most of what was intended to be done in terms of outputs and led to interesting lessons learnt.

4 Contribution to Darwin Initiative Programme Objectives

4.1 Contribution to Global Goals for Sustainable Development (SDGs)

The project aimed to contribute to the following SDGs:

- SDG 1 (End poverty), through supporting organic cotton production with scientific knowledge on pesticide plant species;
- SDG 2 (Promote sustainable agriculture), through promoting use of bio-pesticides as opposed to chemical pesticides;
- SDG 5 (Gender equality), supported by the training of women in organic cotton cultivation techniques and participation in workshops;
- SDG 15 (Sustainable use of terrestrial ecosystems/reduce desertification/land degradation/biodiversity loss), through reducing unsustainable use of wild pesticidal plant resources via cultivation.

4.2 Project support to the Conventions or Treaties (CBD, CMS, CITES, Nagoya Protocol, ITPGRFA)

The project aimed to work with the national focal points in Mali to meet their obligations under the CBD contributing to:

- Raising awareness of the values of (plant) biodiversity and the steps needed to conserve and use it sustainably (Aichi Target 1);
- Governments, business and stakeholders taking steps to keep the use of natural resources well within safe ecological limits (Aichi Target 4);
- Preventing the extinction of threatened species particularly of those most in decline (Aichi Target 12);
- Sharing, transferring and applying scientific knowledge to improve the status and trends of biodiversity (Aichi Target 19);
- Assessing the conservation status of plant species to guide conservation (GSPC 2);
- Preserving threatened species *in-situ* and in national, *ex-situ* seed bank facilities (GSPC Targets 7 & 8);
- All wild harvested plant-based products sourced sustainably (GSPC Target 12);
- Strengthening partnerships and co-operation with appropriate national and international institutions (GSPC Target 16).

However, contact with national focal points was severely limited by travel restrictions due to Ebola in Y1 and terrorist threat in Y2/Y3 such that and only IER project staff were able to make such contact.

4.3 Project support to poverty alleviation

The expected direct and indirect beneficiaries of the project are the 20,820 members of the 5 FENABE cooperatives (67 farmers' groups) in the four regions of Mali. Although the project was designed to make this contribution happen, it could not provide solid evidence to substantiate a positive outcome concerning women and men farmers' income. This was mainly due to a weak design of the outcome and impact monitoring system. Additionally, farmers are exposed to external drivers, such as climate change impacts and unreasonable sale price of organic cotton, making their livelihoods even more vulnerable. However, the most promising indications that income may be positively impacted in the long term are the better yields of organic cotton with the new bio-pesticide formulations in the trial plots of Yanfolila and Kolondiéba as well as the production and sale of *Carapa procera* oil, which enabled FENABE not to have to source extra oil from Guinea.

4.4 Gender equality

Women constitute 20% of the 20,820 farmers of FENABE and often have responsibility roles in cooperatives. Gender equality was supported by the participation of women in training sessions and workshops on organic cotton cultivation techniques, including training in *Carapa procera* and *Balanites aegyptiaca* oil extraction.

4.5 Programme indicators

Did the project lead to greater representation of local poor people in management structures of biodiversity? The project has trained farmers and technical services in biodiversity conservation and management in all the four project areas.

Were any management plans for biodiversity developed? Yes, harvesting pesticide plants from the wild was reduced as a result of the project.

Were these formally accepted? Yes, the participatory work of IER, FENABE and *Eaux et Forêts* with communities has ensured high level of consensus from farmers and the approach has been mainstreamed in Agriculture and Forestry Departments and other relevant institutions via training and project result dissemination workshops.

Were they participatory in nature or were they 'top-down'? How well represented are the local poor including women, in any proposed management structures? As explained above, the new approach to biodiversity management and conservation followed from a participatory process and community consultations and was agreed upon by farmers.

Were there any positive gains in household (HH) income as a result of this project? The project system to monitor outcome and impact indicators was poorly designed and this question cannot be thoroughly answered. However, survey data on average yield of organic cotton (though unreliable due to a suspect overestimation) seem to depict a decrease rather than an increase in production, so positive gains in HH income from on-farm organic cotton are unlikely to have materialised. Additionally, sale price of organic cotton has remained stable across years at CFA 300/kg. Positive gains in HH income may have been generated by production and sale of *Carapa procera* oil, but there is no quantitative evidence to prove it.

How many HHs saw an increase in their HH income? This was not calculated; however, survey data on average yield of organic cotton (though unreliable due to a suspect overestimation) seem to depict a decrease rather than an increase in production, thus positive gains in HH income from on-farm organic cotton are unlikely to have materialised.

How much did their HH income increase (e.g. x% above baseline, x% above national average)? How was this measured? This was not calculated; however, survey data on average yield of organic cotton (though unreliable due to a suspect overestimation) seem to depict a decrease rather than an increase in production, hence positive gains in HH income from on-farm organic cotton are unlikely to have materialised.

Transfer of knowledge

Transfer of knowledge was delivered in different ways throughout the project: training events, dissemination of information, workshops including participation from target institutions, report and research result sharing as well as germination and propagation protocols and standardised formulations of bio-pesticides.

Did the project result in any formal qualifications?

One Ph.D. Degree, three Master's Degrees, six stage completion certificates.

4.6 Capacity building

The project strengthened partners' capacity in conducting research on plant biodiversity conservation and sustainable use. Institutional capacity was also strengthened to provide an enabling environment to farmers seeking viable and sustainable alternatives to high-input commercial crops. Training and dissemination workshops were organised and training sessions were delivered to community members. IER increased its capacity to manage the herbarium and seed bank. A solid partnership was set up with institutions and organisations in Mali, such as IER, DMT, FENABE, Forestry and Agriculture Departments and CMDT. RBG Kew is willing to continue investing efforts in such partnership in future.

5 Sustainability and Legacy

The strategy to deliver sustainability and legacy was to take advantage of IER's ability to influence the national Forestry and Agriculture Departments in Mali and mainstream the proposed project approach. The partnership described above has consolidated the collaboration with DMT in Bamako and with the Department Head, Prof. Rokia Sanogo, promoting in-country research and providing a link to policy makers. Prof. Sanogo is influential with government bodies and advises the Prime Minister.

6 Lessons learned

Overall the project has been significantly impacted by Ebola, terrorism and PI change, none of which could have been foreseen at the project outset. In particular, it has impacted communication and the ability of the lead partner to be engaged in in-country activities and project managing activities with IER in a hands-on manner in line with the GANTT chart. The project has clearly managed to define a list of useful species through knowledge exchange with farmers. This has enabled prioritisation of the species most likely to show pesticidal activity against cotton pests. The project has advanced knowledge on the effectiveness of extracts and compounds from those species against pests. No initial biodiversity survey was carried out and economic and policy targets were overambitious in the first place, making it difficult to realistically assess project contributions to poverty alleviation. The quality of outcome indicators was appropriate, but in quantitative terms the targets set were rather unachievable for a project of such short duration, especially those related to income increase. The need for a better designed outcome monitoring and assessment system together with more tailored targets clearly emerged from this experience.

6.1 Monitoring and evaluation

Problems in communication and travel have hampered M&E efforts by RBG Kew staff during project implementation. Community participatory M&E in Mali has continued via IER working with FENABE and *Eaux et Forêts* both in its headquarters and on farms.

6.2 Actions taken in response to annual report reviews

We thank the DI and the reviewers of the past annual reports. We have reviewed the output assumptions, have attempted to provide evidence of progress as far as possible in this final report, and sought to provide clearer information on progress against the outcome within the constraints of communication with IER. This has been made possible by the fact that Dr. Sidi Sanogo travelled to RBG Kew several times during the extension phase. Other comments and queries raised in past report reviews have been addressed and a number of changes to the project have been made. These have always been discussed between the partners over e-mails, skype and in person when possible.

7 Darwin identity

The DI logo was used on all dissemination and workshop material and reports, including presentations delivered by Kew, IER and FENABE staff. It is also visible on the project web page: https://www.kew.org/science/projects/pesticide-plants-for-organic-cotton-in-mali. The DI was acknowledged orally during workshops and radio transmissions and in the MSc. thesis on germination of *Zanthoxylum species* submitted by Alexis Reynoso.

8 Finance and administration

8.1 Project expenditure

Project spend (indicative) since last annual report	2017/18 Grant (£)	2017/18 Total actual Darwin Costs (£)	Variance %	Comments (please explain any variance)
Staff costs				
Consultancy Costs				
Overhead Costs				
Travel and subsistence				
Operating Costs				
Capital items				
Others				
Audit costs				
TOTAL				

Staff employed (Name and position)	Cost (£)
Paul Wilkin	
Phil Stevenson	
Elena Castillo Lorenzo	
Pablo Gomez Barreiro	
IER	
TOTAL	

Capital items – description	Capital items – cost (£)
TOTAL	

Other items – description	Other items – cost (£)
Development of farmer properties and certification protocols Development of local and investment industrial markets	
TOTAL	

8.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
TRAID matching fund	
TOTAL	

Source of funding for additional work after project lifetime	Total (£)
TOTAL	

8.3 Value for Money

The investment has proven that IER, FENABE and other partners in Mali can work effectively in the area, forming good relationships with communities and providing good training to improve farmers' skills in managing their natural resources in a more sustainable manner. The amount of project activities implemented thanks to DI grant is remarkable.

Annex 1 Project's original (or most recently approved) logframe, including indicators, means of verification and assumptions.

Note: Insert your full logframe. If your logframe was changed since your Stage 2 application and was approved by a Change Request the newest approved version should be inserted here, otherwise insert the Stage 2 logframe.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: The sustainable use and cultivation of useful native plants support biodiversity conservation and poverty reduction in rural Mali. Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources.			
Outcome: The sustainable use and cultivation of pesticide plants for organic cotton production leads to increased income generation among target communities and reduces the loss of plant biodiversity in southern Mali.	1. Native pesticide plants successfully established in community demonstration gardens as farmer field schools in each of the regions by Y3. 2. Important pesticide species show marked reduction in losses, benefitting the conservation of wild populations. 3. Yields of 'first class' organic cotton increased by 5% across target communities, increasing farmers' revenues and securing crop bonuses for reaching organic cotton production targets by Y3. 4. All beneficiary women farmers (20% of FENABE) have increased their income by 10 to 25% in the four regions by Y3. All direct beneficiary men farmers have increased their income by 10 to 25% in the four regions by Y3. 5. >25% of cotton farmers in target communities use optimum standard organic pesticide and treatment regimes, reducing wastage by Y3.	1. Technical reports on species plantations by IER, FENABE and Kew. 2. Vegetation surveys in the four regions at beginning and end of project. 3. FENABE annual reports, household surveys and reports. 4. FENABE annual reports household surveys and reports. 5. Household surveys and technical reports.	1. Plant propagation and analytical research on the target pesticide species does not prove to be exceptionally difficult. 2. The four small-scale producers of organic pesticide can continue to source raw material needed to create the optimal pesticide for organic cotton farmers. 3. The national cotton board (CMDT) maintains its support to organic cotton production and its marketing. 4. Climatic variation does not restrict threaten the viability of pesticide plant cultivation in community gardens. 5. International organic cotton prices do not fall significantly.
Output 1 Identification and authentication of pesticide species currently used by organic cotton farmers in target	1.1 Established base list of pesticide species collated from desk study and questionnaires addressed to organic cotton farmers in the four regions of	1. Verified base list of organic species established and published.	Plant research investigations are successful and not particularly challenging for the target species. The risks of challenging research on

communities.	Mali. 1.2 Collections of specimens of seeds and herbarium vouchers of pesticide species. 1.3 List of pesticidal species that have been authenticated in the field and laboratory, with confirmed scientific and vernacular names.		important compounds and extraction methods can affect the standardisation of pesticide products. However, the combined expertise of Kew and NRI will be mobilised to minimise these risks.
Output 2 Active compounds / ingredients in the key pesticidal plants being used by cotton producers are identified and relative effectiveness of different species established.	2.1 Identification of chemical composition of the key pesticide species. 2.2 Establish pesticidal efficacy of at least six species in laboratory conditions. 2.3 Determine dose of combined ingredients of different species in field tries.	2. Key pesticide species used by cotton producers been studied and their relative effectiveness established and published.	Plant research investigations are successful and not particularly challenging for the target species. The risks of challenging research on important compounds and extraction methods can affect the standardisation of pesticide products. However, the combined expertise of Kew and NRI will be mobilised to minimise these risks.
Output 3 Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers.	3.1 10 farmers from the four regions and FENABE technical team have been trained in producing optimum plant-based products for organic crop production. 3.2 Small-scale supply branches of standardised pesticide products set up in each of the four regions managed by the trained farmers as inputs. 3.3 Specific market niche of pesticidal plant products identified and investments established.	3. A standardised production unit and usage methods of pesticide plant products created in each of the regions for organic farmers.	Community members remain engaged, receptive to training and provide labour and land for growing and maintaining priority species in the woodlots. This risk is minimised because organic production is the identity of the target MOBIOM/FENABE group of farmers, who had already approached Kew to request a support in cultivating native pesticide species.
Output 4 Four community demonstration gardens established to strengthen the capacity of target communities to cultivate pesticidal plants. This will provide an alternative to wild plant harvesting and ensure sustainable supplies of key plants in the future.	4.1 Maintenance of demonstration gardens of at least 1ha in each of the 4 regions, planted with key pesticide species seedlings. 4.2 Seed supply and increased seedling production of pesticide species in nurseries to ensure individual needs and continuity of cultivation. 4.3 Assessing and annually collecting	4. A community garden/woodlot of pesticide plant species created in each of the four regions.	Seed germination and seedling production of the target pesticide species prove to be exceptionally difficult. Seed germination of many wild species is not always straightforward and can be tricky in terms of their dormancy breaking (seed pre-treatments and handling) and their growth in the

	data on survival and growth of seedlings in the plots.		nursery. However, Kew's excellent seed laboratory and expertise will help overcome any such challenges within the project life time.
Output 5 Increased awareness of pesticidal plant use for organic cotton production among policy makers and cotton growing communities in Mali (CMDT/Dept. of Agriculture/Dept. of Forestry).	5.1 CMDT/Agriculture/Forestry use project guidelines for managing native pesticidal plants. 5.2 Dept. of Agriculture and Forestry recognise the importance of local useful trees/plants and work on reversing farming practices' focus on land clearing before planting crops. 5.3 CMDT/Agriculture/Forestry integrate the ecological resilience of farming system in rural communities' development via project final workshop in West-Africa, where Forestry agents would promote the project methodology.	5. Reference materials for the identification and cultivation of key pesticide species in Mali produced and distributed to farmers.	No risk/assumption in logframe.
Output 6 Assessment of potential climate risks that may impact pesticidal species.	6.1 Assessment of potential climate risks that may impact pesticidal species.	6. Production of a report on climate change mitigation.	Climatic data available at local scale.

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 Survey through questionnaires and desk study on pesticide plant species used in organic cotton production in Mali.

1.2 Field trips and collection of pesticidal species specimens (known scientific and local names, seeds, herbarium specimens and photographs) and vegetation survey:

- Further work is required due to inadequately air-dried samples being sent from Mali in 2015 and failure to identify the components at Kew (due to a crash in *Helicoverpa armigera* colony);

- One-off survey of the vegetation by IER to survey current state of wild pesticidal plant populations around villages which have occurred spontaneously, possibly coupled with questions on their historical abundance in socio-economic survey.

1.3 Verification research on collected specimens at Kew Herbarium and MSB:

- Further research is required to evaluate the toxic effects of the compounds on the insects in the time period after feeding. *Helicoverpa armigera* supply issues to be resolved and further samples to be transferred from Mali;

- Further research is required on germination tests at Kew MSB as well as propagation and cultivation of pesticidal plants in-country nursery.

1.4 Compilation of data from Kew and other databases, regarding candidate species seed collecting, handling, germination and propagation. Preparation of species pages (including field photographs).

2.1 Collection of specimens for by-product extraction and study in the laboratories in Mali and at Kew and efficient extractions by communities in Mali.

2.2 New bio-assays and identification of chemical composition of collected specimens, carried out mainly at Kew by Paul Green:

- Production of an article on the pesticidal plants used to protect organic cotton.

2.3 Tests on pests of the extracted compounds in the field with communities, leading to standardisation of ingredients/composition and guidelines for use.

2.4 Present research outcomes at AETFAT conference in May 2017 (oral presentation).

3.1 Develop improved methods for harvesting and efficient protocols for by-product extraction that optimise bioactivity and reduce over-collection and wastage.

3.2 Training workshops for pesticidal plants producers on preparation and presentation of standardised products (at least two trainer farmers per region).

3.3 Develop IPR, farmers' ownership and product registration protocols for organic cotton production according to the regulations in place in Mali.

3.4 Exploit local industrial investment opportunities and economic markets to promote the use of optimum standard organic pesticides, similar to the traditional medicine model in Mali.

4.1 Generate data on propagation methods for listed pesticidal plant species, rare and/or commonly used by farmers in the four regions (also for journal articles).

4.2 Train, collect seeds of selected key species and produce enough seedlings in community nurseries.

4.3 Plant out seedlings in communal demonstration plots (at least 1ha x 4) and establish community ownership for long term management and further development.

4.4 Organise farmer and NGO workshops to inform the wider farming community about sustainable use of pesticidal plants and their cultivation.

4.5 The benefits of cultivating pesticidal plants for organic production promoted through farming fairs, exhibitions (video) and local radio.

4.6 Reproduction of guide/hand book, leaflets and posters through Kew Publishing (in local language).

5.1 Present research findings and guidance to and organise farmers' field visits of woodlots for CMDT directorate who provides technical advice to farmers regarding cotton production.

5.2 Present project findings and guidance to and organise farmers' field visits of woodlots for Dept. of Agriculture directorate who provides technical advice to farmers regarding sustainable farming.

5.3 Present project findings and guidance to and organise farmers' field visits of woodlots for Dept. of Forestry who manages and advises farmers regarding conservation and sustainable use of non-timber forest products.

5.4 Second socio-economic survey to be carried out in Mali by IER (overall method to measure the 5 indicators of the outcome of the project).

6.1 Assessment of potential climate risks for pesticide plants important for organic cotton production:

- Run a literature review and determine which pesticide species are more at risk and in which organic cotton production areas;

- Focus the review on the response of key pesticide species to climate change and on modelling-based research, supported by acquisition of historical climate data and predictive climate models in Mali.

Annex 2 Report of progress and achievements against final project logframe for the life of the project

Project summary	Measurable Indicators	Progress and Achievements April 2014 – February 2018	Actions required/planned for next period
Impact The sustainable use and cultivation of useful native plants support biodiversity conservation and poverty reduction in rural Mali.		Most significant progress: 1) Seed cotton yield in 2017 in the trial plots of Kolondiéba was 649,60 kg/ha with one of the new bio-pesticide formulations and 524,60 kg/ha with the former one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the former one. This implies a potential long-term livelihood benefit for the 20,820 members of the 5 cooperatives (67 farmers' groups) of FENABE (Annex 12). 2) *Carapa procera* oil production was enough to supply local demand, without having to purchase it from Guinea (Annex 18). 3) Scale of planting of pesticide species 25,5 ha in total, with 10,200 plants of seven species in 38 farms. Nursery supplied a total of 34,430 seedlings to demonstration plots and members of organic cotton producers' cooperatives. 4) Decreased number of core species used by farmers to produce standardised bio-pesticides and potentially harvested from the wild: from ten in 2015 to five in 2017. In 2015, 40% of the surveyed farmers harvested pesticide plants from the wild, while in 2017 only 15% did so. These data show a change in behaviour and by assumption a reduction in losses of important pesticide species.	N/A

Outcome The sustainable use and cultivation of pesticide plants for organic cotton production leads to increased income generation among target communities and reduces the loss of plant biodiversity in southern Mali.	1) Native pesticide plants successfully established in community demonstration gardens as farmer field schools in each of the regions by Y3. 2) Important pesticide species show marked reduction in losses, benefitting the conservation of wild populations. 3) Yields of 'first class' organic cotton increased by 5% across target communities, increasing farmers' revenues and securing crop bonuses for reaching organic cotton production targets by Y3. 4) All beneficiary women farmers (20% of FENABE) have increased their income by 10 to 25% in the four regions by Y3; All direct beneficiary men farmers have increased their income by 10 to 25% in the four regions by Y3. 5) >25% of cotton farmers in target communities use optimum standard organic pesticide and treatment regimes, reducing wastage by Y3.	1) Four community gardens established, replenished, monitored and maintained. A total of seven species were planted in 25,5 ha in Bougouni, Yanfolila, Bla and Kolondiéba across 38 farms for a total of 10,200 plants (density 5 m by 5 m). Seedlings used for replenishment were around 5,000. Ziziphus mauritiana was planted only in Bla and was not maintained after Y1. Data on survival and growth rate were generated via bio-physical evaluations in Y2 and Y3 and are available. Five village nurseries of approximately 0.5 ha each were established to produce seven native pesticide species and seedlings produced were planted. A total of 34,430 seedlings were distributed for the demonstration plots and members of organic cotton producers' cooperatives in the four regions (Annex 19). 2) The percentage of surveyed farmers harvesting pesticide plants from the wild decreased from 40% in 2015 to 15% in 2017. The number of core species used to produce standardised bio-pesticides and potentially harvested from the wild decreased from ten in 2015 to five in 2017. These data show a change in behaviour and by assumption a reduction in losses of important pesticide species (Annex 7). 3) Seed cotton yield in 2017 in the trial plots of Kolondiéba was 649,60 kg/ha with one of the new bio-pesticide formulations and 524,60 kg/ha with the former one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the former one (Annex 12). The socio-	

		economic/ethno-botanical survey revealed that average yield of organic cotton in 2015 was 1059 kg/ha and 925 kg/ha in 2017 in the regions of Sikasso, Ségou and Kayes, showing a decrease of 13% (Annex 7). This information does not seem to be reliable (overestimation) when compared to yields from trial plots. 4) The socio-economic/ethno-botanical survey conducted in 2015 and 2017 had only seven women farmers in the sample, the number is too small to assess Indicator 4. Increase in income of men farmers is difficult to prove as overall on-farm production of organic cotton seems to have decreased (Annex 7). 5) The socio-economic/ethno-botanical survey revealed that 94% of the sampled farmers use bio-pesticides (70% according to the information on farmers using both organic and chemical pesticides). However, it also revealed that farmers using only chemical pesticides are 28%.	

Output 1. Identification and authentication of pesticide species currently used by organic cotton farmers in target communities.	1.1) Established base list of pesticide species collated from desk study and questionnaires addressed to organic cotton farmers in the areas of Bougouni, Yanfolila, Kolondiéba and Bla in Mali. 1.2) Collections of specimens of seeds and herbarium vouchers of pesticide species. 1.3) List of authenticated pesticide species with confirmed scientific and vernacular names.	1.1) Base list of 26 species established from desk study and questionnaires administered in the regions of Sikasso, Ségou, Koulikoro and Kayes (Annex7, Annex 8). 1.2) 104 voucher specimens of 65 pesticide/multipurpose species and 45 seed accessions stored in Mali during project implementation. Collection of 416,000 seeds of *Nicotiana tabacum* and relevant specimen voucher sent to Kew in 2014 and stored in the MSB. Plant samples of *Carapa procera, Chamaecrista nigricans, Khaya senegalensis, Securidaca longipedunculata, Bobgunnia madagascariensis*, *Balanites aegyptiaca* and *Cassia sieberiana* sent to Kew in Y1 and Y2 for bio-assays. Collections of seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa* sent to Kew in 2017 for germination tests (Annex 9, Annex 10, Annex 17, 17a). 1.3) List of 34 pesticide species authenticated and scientific and vernacular names confirmed plus data from bio-assays and field experiments collected (Annex 7, Annex 8, Annex 10). Indicators are appropriate.
Activity 1.1: Survey through questionnaires and desk study on pesticide plant species used in organic cotton production in Mali.		Questionnaires were administered in early 2015 (Annex 7). Data on the initial 26 species were entered into a database (Annex 8 for a screenshot). These data describe different types of local preparation of pesticide extracts, farmers' dosages and frequency of use of these bio-pesticides in addition to taxonomic and distribution data. Individual interviews with producers took place to gather information on plant and crop protection.
Activity 1.2: Field trips and collection of pesticide species specimens (known scientific and local names, seeds, herbarium specimens and photographs) and vegetation survey.		Unknown or unidentified species were identified by specialist botanists from IER together with local practitioners while administering the questionnaire in 2015. Bio-pesticide tests, plant production, propagation in laboratory and specimens were collected for 18 species. Ethno-botanical surveys were carried out in Y2 and Y3 to observe the seedbeds, authenticate pesticidal plants and collect specimens and seeds. Information gathering continued in 2017 to investigate the use of pesticide plants by producers of organic cotton and other organic crops in the areas of Bougouni, Yanfolila, Kolondiéba and Bla. In-depth consultations with resource farmers were held to make species vernacular names uniform (Annex 7, Annex 8, Annex 18).
Activity 1.3: Verification research on collected specimens at Kew Herbarium and Millennium Seed Bank (MSB).		Specialist botanists from IER visited farmers in Y1 and identified all unknown species. Germination and conservation tests were conducted in Mali in Y2. The seeds of pesticidal species were harvested for the production of plants. Ethno-botanical surveys and seed and herbarium collections were conducted throughout the project lifespan. The authentication of pesticidal plants collected was carried out by the IER laboratory of Sikasso using available databases. Seeds and herbarium specimens of 15 species were collected and sent to Kew (Annex 7,

		Annex 8, Annex 9, Annex 10, Annex 17, 17a).
Activity 1.4: Compilation of data from Kew and other databases, regarding candidate species seed collecting, handling, germination and propagation. Preparation of species pages (including field photographs).		A database of pesticide plant species was created in Y1 (Annex 8 for a screenshot). Data on 34 species including those from ethno-botanical surveys and interviews are now included in the database. They provide information on local preparation methods for pesticide extracts, farmers' dosages and frequency of use of these bio-pesticides, in addition to taxonomic and distribution information. Germination and viability testing data were added in Y3 (Annex 17, 17a). A species page was produced for *Carapa procera*.
Output 2. Active compounds/ingredients in the key pesticide plants being used by cotton producers are identified and relative effectiveness of different species established.	2.1) Identification of chemical composition of the key pesticide species. 2.2) Establishment of pesticidal effectiveness and efficiency of at least six species in laboratory conditions. 2.3) Establishment of dosages of combined ingredients of different species through field trails.	2.1) Components not identified at Kew due to crash in *Helicoverpa armigera* colony. Classes of compounds in six species were identified by DMT in Mali. DMT reports examine content of insecticidal active ingredients (mg and %) in extracts of pesticidal plants (Annex 11). 2.2) Relative effectiveness assessed via bio-assays in seven species at Kew in Y2 an Y3 (Annex 10). 2.3) In Y3, in Mali, 20 ml/kg dosage was tested of *Balanites aegyptiaca* seed oil and 20% extemporaneous solutions of *Chamaechrista nigricans* leaves, *Carapa procera* leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*. It showed no toxic effects after 14 days from the treatment. Dosage of 20 ml/kg of *Carapa procera* oil led to the death of one of the three mice used for the test after 24 hours (Annex 11). At Kew, no mortality was observed over 72 hours (Annex 10). Field data were generated on two new formulations (Annex 12). Seed cotton yield in 2017 in the trial plots of Kolondiéba was 649,60 kg/ha with one of the new formulations and 524,60 kg/ha with the former one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the former one. Indicators are appropriate.
Activity 2.1: Collection of specimens for by-product extraction and study in the laboratories in Mali and at Kew and efficient extractions by communities in Mali.		In Y1, samples of plant fragments of nine important species from different sites and provenances were harvested and extracts were prepared for bio-assays in IER laboratory in Sikasso. The extracts included seed oils of three species, *Balanites aegyptiaca, Carapa procera* and *Lophira lanceolata*. In Y2, collecting of pesticide plant organs continued in villages with the support of facilitators and supervisors. Specimens of collected organs of pesticide plants were packaged in the laboratory of entomology. Tests, which studied the effectiveness of bio-pesticide products used in cotton fields, were completed. Species and formulations adopted were as follows: - Former formulation: seed extracts of *Azadirachta indica* + oil of *Carapa procera* - New formulation (1): stem extracts of *Euphorbia paganorum* + bark

	extract of *Khaya senegalensis* + oil of *Carapa procera* - New formulation (2): plant extract of *Chamaecrista nigricans* + stem extracts of *Euphorbia paganorum* + oil of *Balanites aegyptiaca* In Y3, pesticide plant samples were collected in Mali and sent to Kew for new bio-assays and phytochemical analysis.
Activity 2.2: Bio-assay and identification of chemical composition of collected specimens, carried out mainly at Kew.	Seven species sent to Kew in Y1 and Y2 were evaluated as feeding repellents against cotton bollworm, *Helicoverpa armigera*. They were *Carapa procera, Chamaecrista nigricans, Khaya senegalensis, Securidaca longipedunculata, Bobgunnia madagascariensis*, *Balanites aegyptiaca* and *Cassia sieberiana.* Feeding was repelled by *C. nigricans* and stimulated by extracts from the other species (Annex 10). Tests on extracts from 23 species were undertaken in Mali. Five showed high levels of efficacy against cotton pests. Research on chemical compounds was undertaken in Mali. Laboratory analysis revealed the acidity indices (AI) and the unsaponifiable levels of *Carapa procera* and *Balanites aegyptiaca* oil. The report on chemical compound content of pesticidal plants was submitted by DMT in Y3 (Annex 11). In Y3 research continued at Kew on toxic effects of the compounds on insects in the time period after feeding. During the bio-assays, no mortality was observed after 72 hours from contract with extracts. This included the 1000ppm rotenone positive control, which was expected to be biologically active and cause mortality. Furthermore, the mass of insects tested with treatments increased by 242%-316%, similar to the negative control (Annex 10 and relevant spreadsheet). in Mali, 20 ml/kg dosage was tested of *Balanites aegyptiaca* seed oil and 20% extemporaneous solutions of *Chamaechrista nigricans* leaves, *Carapa procera* leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*. It showed no toxic effects after 14 days from the treatment. The toxic dose would therefore be higher than the tested one. Dosage of 20 ml/kg of *Carapa procera* oil led to the death of one of the three mice used for the test after 24 hours (Annex 11).
Activity 2.3: Tests on pests of the extracted compounds in the field with communities, leading to standardisation of ingredients/composition and guidelines for use.	Seed cotton yield in 2017 in the trial plots of Kolondiéba was 649,60 kg/ha with one of the new formulations and 524,60 kg/ha with the former one. In Yanfolila, the organic cotton yield was 612,20 kg/ha with the new formulation and 599,60 kg/ha with the former one (Annex 12).
Activity 2.4: Present research outcomes at AETFAT conference in May 2017 (oral presentation).	Project background, rationale, activities and outputs were presented at the AETFAT conference in Nairobi in May 2017.

Output 3. Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers.	3.1) Ten farmers from the four regions and FENABE technical team trained in producing optimum standard plant-based products for organic crop production. 3.2) Small-scale supply branches of standardised pesticide products set up in each of the four regions managed by the trained farmers as inputs. 3.3) Specific market niche of plant products and investments established.	3.1) Two training workshops were held in Y2. Two facilitators from MOBIOM, which then became FENABE, attended with 14 women (cooperative secretaries) who disseminated knowledge back to cooperative members. Two village facilitators in Ifola were trained in *Balanites aegyptiaca* oil extraction techniques. Women in Ziekorodougou were trained in *Carapa procera* oil extraction techniques. In the second half of Y3, a training workshop was held in Tamale, Ghana (security reasons). It was organised in close collaboration with FENABE and was attended by representatives from five farmers' cooperatives in Yanfolila, Madina-Bougouni, Bla, Boyi-Kolondièba and Samguela-Yanfolila. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. After Tamale, three restitution workshops were organised in Niala, Yanfolila and Madina-Diawara. A workshop was held in Bougouni on 9-10 Jan 2018 to validate FENABE/IER studies on harvest and production sites of bio-pesticides, on farmers' practices and knowledge on bio-pesticides, and on potential climate change impacts on pesticidal plants. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni et Yanfolila (TRAID matching funds). They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). They were organised by FENABE and animated by IER, thanks to TRAID matching fund, and gathered 125 participants from Yorosso, Bla, Bougouni, Kita and Yanfolila. A desk study was conducted at Kew on seed storage, dormancy and germination of key pesticidal plants. Germination tests were run in 2017 at Kew on seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa.* Results were disseminated and relevant leaflets were produced in French during the extension phase of Y3 (Annex 13, Annex 14, Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20). 3.2) Two cooperatives (Samaguéla and Ziékorodougou) were equipped for Carapa procera oil production. A system of production/supply was established by individuals using facilities for oil extraction. FENABE conducted a study on harvest and production sites of bio-pesticides, which was validated at a workshop held in Bougouni on 9-10 Jan 2018 (Annex 18). 3.3) Niche market established through *Azadirachta indica extract and Carapa procera* oil production sale. Assessment conducted by FENABE on broader commercial potential for optimum standard organic pesticides and validated at a workshop held in Bougouni on 9-10 Jan 2018 (Annex 18). Indicators are appropriate.
Activity 3.1: Develop improved methods for harvesting and efficient protocols for by-product extraction that optimise bioactivity and reduce over-collection and		Studies on extraction of oil from *Balanites aegyptiaca* and *Zanthoxylum zanthoxyloides* for use as adjuvants were conducted in Mali in Y2 and Y3. In Y3

wastage.	training was delivered in Mali in: - *Balanites aegyptiaca* and *Carapa procera* oil extraction techniques; - Preparation and use of bio-pesticides; - Identification of pests; - *Carapa procera* fruit harvesting (two sessions). Training sessions addressed only women or mixed participants (27% women).
Activity 3.2: Training workshops for pesticide producers on preparation and presentation of standardised products (at least two trainer farmers per region).	A training session was organised in Y2 on the oil extraction techniques of *Carapa procera*. Ten women from the cooperatives in Bougouni and Yanfolila benefited from this training. Three nurserymen were trained in seed harvesting and plant production techniques in the province of Bla. Further farmers were trained in planting techniques and plot-based pesticide plants and food plants were installed in the farms. In the second half of Y3, a workshop was held in Tamale, Ghana (security reasons). It was organized in close collaboration with FENABE and was attended by representatives from five farmers' cooperatives in Yanfolila, Madina-Bougouni, Bla, Boyi-Kolondièba and Samguela-Yanfolila. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. After Tamale, three restitution workshops were organised in Niala, Yanfolila and Madina-Diawara. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni et Yanfolila (TRAID matching funds). They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). They were organised by FENABE and animated by IER, thanks to TRAID matching fund, and gathered 125 participants from Yorosso, Bla, Bougouni, Kita and Yanfolila. A desk study was conducted at Kew on seed storage, dormancy and germination of key pesticidal plants. Germination tests were run in 2017 at Kew on seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa.* Results were disseminated and relevant leaflets were produced in French during the extension phase of Y3 (Annex 13, Annex 14, Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20).
Activity 3.3: Develop IPR, farmers' ownership and product registration protocols for organic cotton production according to the regulations in place in Mali.	In Y2 a training session was held on techniques for extracting oil from *Balanites aegyptiaca*. Fourteen women from the cooperatives in Bla, Kolondiéba, Kita and Kolokani benefited from this training. The training was followed by a practical session on the preparation and use of bio-pesticide products. A survey was conducted by FENABE in October 2017 on a sample of 100 farmers in the areas of Bla, Bougouni, Kita, Yanfolila and Yorosso. The study led to the recognition and description of six standardised formulations of biological pesticides adopted by farmers. The results were validated at a workshop held in Bougouni in Jan

		2018 (Annex 18).
Activity 3.4: Exploit local industrial investment opportunities and economic markets to promote the use of optimum standard organic pesticides, similar to the traditional medicine model in Mali.		Two cooperatives (Samaguéla and Ziékorodougou) were equipped for *Carapa procera* oil production. A system of production/supply was established by individuals using facilities for oil extraction. Niche market was established through *Azadirachta indica extract and Carapa procera* oil production sales. In October 2017 FENABE conducted a study in Yanfolila and Kita to assess the potential for further development of local markets and investments on production of optimum standard organic pesticides. The study, which was validated at a workshop held in Bougouni in Jan 2018, confirmed the commercial potential of *Azadirachta indica extracts and Carapa procera* oil (Annex 18).
Output 4. Four community demonstration gardens established to strengthen the capacity of target communities to cultivate pesticide plants. This will provide an alternative to wild plant harvesting and ensure sustainable supplies of key plants in the future.	4.1) Establishment and maintenance of demonstration gardens of at least 1ha in each of the four regions, planted with key pesticide species seedlings. 4.2) Seed supply and increased seedling production of pesticide species in nurseries to ensure individual needs and continuity of cultivation. 4.3) Assessing and annually collecting data on survival and growth of seedlings in the plots.	4.1) Four community gardens established, replenished, monitored and manged. A total of seven species were planted in 25,5 ha in Bougouni, Yanfolila, Bla and Kolondiéba across 38 farms for a total of 10,200 plants (density 5 m by 5 m). Seedlings used for replenishment were around 5,000. Species planted were *Adansonia digitata, Carapa procera, Faidherbia albida, Khaya senegalensis, Parkia biglobosa, Tamarindus indica and Ziziphus mauritiana. Ziziphus mauritiana* was planted only in Bla and was not followed after Y1. Data on survival and growth rate were generated via bio-physical evaluations in Y2 and Y3 and are available (Annex 19). 4.2) Five village nurseries of approximately 0.5 ha each were established to produce seven native pesticide species and seedlings produced were planted. A total of 34,430 seedlings were distributed for the demonstration plots and members of organic cotton producers' cooperatives in the four regions. Seeds were sourced from within Mali at a sufficient level. 4.3) Data on survival and growth rate were generated in Y2 and Y3 via bio-physical evaluations of 10,200 pesticide plants (Annex 19). Indicators are appropriate.
Activity 4.1: Generate data on propagation methods for listed pesticide plant species, rare and/or commonly used by farmers in the four regions (also for journal articles).		In Y1 and Y2, data collection on seedling production and on species propagation protocols took place in three village nurseries in Segou and Sikasso. Community demonstration plots were installed. The species produced were *Adansonia digitata, Khaya senegalensis, Tamarindus indica, Ziziphus mauritiana, Carapa procera, Faidherbia albida* and *Parkia biglobosa*. An example of information on propagation methods as well as plant description, phenology, distribution, usage, collection and seed conservation and trade is available for *Carapa procera*. Management and monitoring of demonstration plots continued in Y3 and they were replenished.
Activity 4.2: Train, collect seeds of selected key species and produce enough seedlings in community nurseries.		In Y1 seeds of 12 species were collected and seedlings produced in two community nurseries. In Y2 stakeholders from 3 community nurseries in Bla were

	equipped (nursery material and seeds) and trained in seed harvesting techniques, germination physiology (6 trainees) and seedling production.
Activity 4.3: Plant out seedlings in communal demonstration plots (at least 1ha x 4) and establish community ownership for long term management and further development.	Four community gardens established, replenished, monitored and manged. A total of seven species were planted in 25,5 ha in Bougouni, Yanfolila, Bla and Kolondiéba across 38 farms for a total of 10,200 plants (density 5 m by 5 m). Seedlings used for replenishment were around 5,000. Species planted were *Adansonia digitata, Carapa procera, Faidherbia albida, Khaya senegalensis, Parkia biglobosa, Tamarindus indica and Ziziphus mauritiana. Ziziphus mauritiana* was planted only in Bla and was not followed after Y1. Demonstration plots of pesticide and food plants set up in Y1 and Y2 were monitored, protected and evaluated. Data on survival and growth (height and diameter) rate were generated via bio-physical evaluations in Y2 and Y3 and are available (Annex 19). During dry season, farmers watered the plants and monitored plots against wandering animals. Activities continued in Y3 in the 38 farm plantations, where six species were replenished. Five village nurseries of approximately 0.5 ha each were established to produce seven pesticide species and seedlings produced were planted. A total of 34,430 seedlings were distributed for the demonstration plots and members of organic cotton producers' cooperatives in the four regions. Seeds were sourced from within Mali at a sufficient level (Annex 19).
Activity 4.4: Organise farmer and NGO workshops to inform the wider farming community about sustainable use of pesticide plants and their cultivation.	A two-day workshop entitled "Pesticidal plants: Their safe and effective use in pest control" was jointly organised by Kew and the Natural Resources Institute at the University for Development Studies in Tamale, Ghana, on 8-9 June 2017. A total of 17 Malian participants attended the workshop and transferred knowledge back to Mali. They were six farmers from five different cooperatives, three representatives from IER and three from FENABE as well as five policy-makers from State Departments of Forestry and Agriculture. Thanks to matching funds from TRAID, three members of the *Organisation Béninoise pour la Promotion de l'Agriculture Biologique* could also attend the workshop. It focused on scientific knowledge concerning cultivation of pesticidal plants and on raising awareness of their benefits among policy makers. It included theoretical and practical training to farmers in preparing and testing bio-pesticide formulations that they disseminated to cooperative members once back in Mali (Annex 13).
Activity 4.5: The benefits of cultivating pesticide plants for organic production promoted through farming fairs, exhibitions (video) and local radio.	Four radio transmissions as media coverage of training sessions were broadcast in Bambara by Radio Wassoulou in Yanfolila, Radio Bendougou in Bla, Radio Kafo-Kan in Boufouni and Radio Nèèma in Yorosso (recordings available). In Y3 a radio program in Bambara was produced for the promotion of organic pesticides. It aimed to sensitise and inform producers on the benefits of organic pesticides. A workshop on new pesticide formulations held during the extension phase of Y3 also benefited from radio media coverage (Annex 16). A project web page was set up: https://www.kew.org/science/projects/pesticide-plants-for-organic-cotton-in-mali

Activity 4.6: Reproduction of guide/hand book, leaflets and posters through Kew Publishing (in local language).		A handbook in French entitled "*Guide des plantes pesticides, optimisation des plantes pesticides: technologie, innovation, sensibilisation & réseaux*" was produced from the English version developed by ICRAF and handed out in electronic format to workshop participants in Tamale in June 2017, together with other training material in French (Annex 14). Leaflets on germination of key species were produced and disseminated thanks to TRAID matching funds.
Output 5. Increased awareness of pesticide plant use for organic cotton production among policy makers in Mali (CMDT/Dept. of Agriculture/Dept. of Forestry).	5.1) CMDT/Agriculture/Forestry use project guidelines for managing native pesticide plants. 5.2) Dept. of Agriculture and Forestry recognise the importance of local useful trees/plants and work on reversing farming practices' focus on land clearing before planting crops. 5.3) CMDT/Agriculture/Forestry integrate the ecological resilient of farming system in rural communities' development.	5.1) The 2014/2015 campaign results were presented to farmer cooperatives. Results of subsequent campaigns were presented to the Departments of Agriculture and Forestry and to CMDT at national planning workshops. A two-day workshop was held in Tamale, Ghana, on 8-9 June 2017. It focused on scientific knowledge concerning cultivation of pesticidal plants and on raising awareness of their benefits among policy makers. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. After Tamale, three restitution workshops were organised in Niala, Yanfolila and Madina-Diawara. These events were attended by the national institutions involved, including the *Chambre d'Agriculture*, and relevant reports were shared. CMDT did not attend the workshop in Tamale due to a resource issue. A workshop was held in Bougouni on 9-10 Jan 2018 to validate FENABE/IER studies on harvest and production sites of bio-pesticides, on farmers' practices and knowledge on bio-pesticides, and on potential climate change impacts on pesticidal plants. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni and Yanfolila. They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). They were organised by FENABE and animated by IER, thanks to TRAID matching fund, and gathered 125 participants from Yorosso, Bla, Bougouni, Kita and Yanfolila. A desk study was conducted at Kew on seed dormancy and germination of key pesticidal plants. Germination tests were run in 2017 at Kew on seeds of *Hyptis spicigera, Hyptis suaveolens, Zanthoxylum zanthoxyloides, Nicotiana tabacum, Opilia celtidifolia, Pentadesma butyracea, Azadirachta indica and Lannea microcarapa.* Results were disseminated and relevant leaflets were produced in French during the extension phase of Y3 (Annex 13, Annex 14, Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20). 5.2) This activity aimed to help implement the National Forest Code (1999). *Eaux et Forets* (Dept. of Forestry) are intermediary IER partners at field level and contribute to disseminating the community garden approach. Information on sound sowing practices is presented in the website of IER. 5.3) A two-day workshop was held in Ghana in 2017, followed by restitution workshops in Mali. Training workshops on biological pesticides were held in 2018 (see Indicator 5.1). CMDT and the targeted State Departments started discussions with stakeholders such as HELVETAS (Annex 13, Annex 14, Annex

		15, Annex 16). Indicators are appropriate.
Activity 5.1: Present research findings and guidance to and organise farmers' field visits of woodlots for CMDT directorate who provides technical advice to farmers regarding cotton production.		The 2014/2015 campaign results were presented to farmer cooperatives. MOBIOM provided a technical report of activities. The results of the last two campaigns were disseminated among farmers and technical services: Departments of Agriculture and Forestry, CMDT and FENABE. A two-day workshop was held in Tamale, Ghana, on 8-9 June 2017. It focused on scientific knowledge concerning cultivation of pesticidal plants and on raising awareness of their benefits among policy makers. The "Handbook on pesticidal plants" by ICRAF was translated into French and disseminated along with other training material in French. Dissemination workshops were organised in Niala, Yanfolila and Madina-Diawara following the international workshop in Tamale. A workshop was held in Bougouni on 9-10 Jan 2018 to validate FENABE/IER studies on harvest and production sites of bio-pesticides, on farmers' practices and knowledge on bio-pesticides, and on potential climate change impacts on pesticidal plants. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni and Yanfolila. They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage). RBG Kew provided scientific information on germination of key pesticide species that was disseminated (Annex 13, Annex 14, Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20).
Activity 5.2: Present project findings and guidance to and organise farmers' field visits of woodlots for Dept. of Agriculture Directorate who provides technical advice to farmers regarding sustainable farming.		The 2014/2015 campaign results were presented to the farmer cooperatives. Results of subsequent campaigns were presented to the Department of Agriculture and the Department of Forestry. Dissemination workshop of project results were held in Mali in Y3 following the international workshop in Tamale. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018 in Boura, Niala, Bougouni and Yanfolila. They addressed producers and technical services (CMDT, Agriculture, Forestry, *Chambre d'Agriculture*, Phytosanitary Service and Community Radio for media coverage).

		RBG Kew provided scientific information on germination of key pesticide species that was disseminated. Activities 5.2 and 5.3 were merged because two representatives from the Directorate of Bougouni, Department of Agriculture, attended the workshop in Tamale (Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20).
Activity 5.3: Present project findings and guidance to and organise farmers' field visits of woodlots for Dept. of Forestry who manages and advises farmers regarding conservation and sustainable use of non-timber forest products.		The 2014/2015 campaign results were presented to the farmer cooperatives. Results of subsequent campaigns were presented to the Department of Agriculture and the Department of Forestry. Following the workshop in Tamale, dissemination workshops were organised in Mali in Y3. Training workshops on the new formulations of biological pesticides were held on 17-21 Feb 2018. RBG Kew provided scientific information on germination of key pesticide species that was disseminated. Activities 5.2 and 5.3 were merged because one representative from the Directorate of Bougouni, Department of Forestry, attended the workshop in Tamale (Annex 15, Annex 16, Annex 17, 17a, Annex 18, Annex 20).
Activity 5.4: Second socio-economic survey to be carried out in Mali by IER (overall method to measure the five indicators of the outcome of the project).		The second socio-economic survey was carried out by IER in December 2017 on a sample of 65 farmers in the areas of Yanfolila, Bougouni, Bla and Kita, and provided data on most of the project outcome indicators (Annex 7).
Output 6. Assessment of climate change impact on pesticidal plant species.	6.1 Climate change impact on pesticidal plant species assessed.	Response of key pesticide species to climate change assessed through surveying farmers' experience in the areas of Bougouni, Bla, Yanfolila, Yorosso and Kita (100 farmers). Risks highlighted of diminished seed production, decreased density and mortality. Three species emerged for their potential to adapt: Azadirachta indica, Khaya senegalensis and Securidaca longipedunculata. The assessment was validated at a workshop held in Bougouni on 9-10 Jan 2018 (Annex 20). Indicator is appropriate.
Activity 6.1: Run a literature review and determine which pesticide species are more at risk and in which organic cotton production areas.		Some literature review was conducted, but the assessment focused mainly on survey results and farmers' experience of climate change impact on pesticidal plant species in the areas of Bougouni, Bla, Yanfolila, Yorosso and Kita. Risks were highlighted of diminished seed production, deceased density and mortality (Annex 20).
Activity 6.2: Focus the review on the response of key pesticide species to climate change and on modelling-based research, supported by acquisition of historical climate data and predictive climate models in Mali.		The study focused mainly on data collected through household questionnaires to assess response of key pesticide species to climate change. Three species emerged for their potential to adapt: *Azadirachta indica*, *Khaya senegalensis* and *Securidaca longipedunculata* (Annex 20).

Annex 3 Standard Measures

Code	Description	Total	Nationality	Gender	Title or Focus	Language	Comments
Training Measures							
1a	Number of people to submit PhD thesis						
1b	Number of PhD qualifications obtained	1	Mali	M	Essais de germination et conservation de fruits et graines de quelques espèces ligneuses à usages multiples au Mali	French	
2	Number of Masters qualifications obtained	3	Mali	2 M, 1 F	Germination of three savannah species: *Lannea microcarpa, Cordylla pinnata* and *Ximenia américana.*	French	
3	Number of other qualifications obtained	6 stage certificates	Mali	3 M, 3 F	Stage reports on germination of *Cassia nigricans, Entada africana, Bobgunnia madagascariensis, Lophira lanceolata, Strychnos spinosa* and *Opilia amentacea.*	French	

4a	Number of undergraduate students receiving training	26	Mali	17 M, 9 F	Plant production techniques	French	
4b	Number of training weeks provided to undergraduate students	169	Mali	17 M, 9 F	Plant production techniques	French	
4c	Number of postgraduate students receiving training (not 1-3 above)	5	Mali	2 M, 3 F	Seed preparation and storage techniques	French	
4d	Number of training weeks for postgraduate students	141	Mali	2 M, 3 F	Seed preparation and storage techniques	French	
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification (e.g., not categories 1-4 above)						
6a	Number of people receiving other forms of short-term education/training (e.g., not categories 1-5 above)						
6b	Number of training weeks not leading						

	to formal qualification						
7	Number of types of training materials produced for use by host country(s) (describe training materials)	4 training reports and 4 radio transmissions as media coverage of the training sessions broadcast by Radio Wassoulou in Yanfolila, Radio Bendougou in Bla, Radio Kafo-Kan in Boufouni and Radio Nèèma in Yorosso (recordings available).	Mali		*Balanites aegytiaca* oil extraction, *Carapa procera* seed processing, recognition and identification of cotton pests, training of producers in the preparation and use of new bio-pesticide formulations.	Bambara	
Research Measures		**Total**	**Nationality**	**Gender**	**Title**	**Language**	**Comments/ Weblink if available**
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing						

	agencies in the host country						
10	Number of formal documents produced to assist work related to species identification, classification and recording.						
11a	Number of papers published or accepted for publication in peer reviewed journals	1	Mali	M	Gravimetric sorting to improve germination of *Anogeissus leiocarpa* seed lots	English	Seed Science and Technology Vol 43: 318-323 http://www.ingentaconnect.com/content/ista/sst
11b	Number of papers published or accepted for publication elsewhere	1	Mali	M	Essais de germination et conservation de fruits et graines de quelques espèces ligneuses à usages multiples au Mali	French	PhD Thesis University of Ghent, Belgium
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country						
12b	Number of						

	computer-based databases enhanced (containing species/genetic information) and handed over to host country						
13a	Number of species reference collections established and handed over to host country(s)						
13b	Number of species reference collections enhanced and handed over to host country(s)	Herbarium of 65 pesticide and food plant species.					Stored at IER's Forestry Programme in Sikasso.

Dissemination Measures		**Total**	**Nationality**	**Gender**	**Theme**	**Language**	**Comments**
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	3	Mali	16M, 4F	Dissemination workshops of project results.	Bambara	
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	19	Mali, Benin	18M, 1F	Workshop on "Pesticidal Plants: Their safe and	English, French	

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
					effective use in pest control", held in Tamale, Ghana.		

Physical Measures		Total	Comments
20	Estimated value (£s) of physical assets handed over to host country(s)		
21	Number of permanent educational, training, research facilities or organisation established		
22	Number of permanent field plots established	38 individual plantations (25,5 ha)	Demonstration plantations were installed in farms to build the capacity of target communities to cultivate pesticide plants. The area of the plots varied from 0.25 ha to 1 ha. Seven species for a total of 10200 plants were planted.

Financial Measures		Total	Nationality	Gender	Theme	Language	Comments
23	Value of additional resources raised from other sources (e.g., in addition to Darwin funding) for project work	£83,182	UK - TRAID				

Annex 4 Aichi Targets

	Aichi Target	Tick if applicable to your project
1	People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	√
2	Biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	
3	Incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	
4	Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	√
5	The rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	
6	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	
7	Areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	
8	Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	
9	Invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	
10	The multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	
11	At least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.	
12	The extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	√
13	The genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	

14	Ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	
15	Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	
16	The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	
17	Each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	
18	The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	
19	Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	√
20	The mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.	

Annex 5 Publications

Title	**Type** (e.g. journals, manual, CDs)	**Detail** (authors, year)	**Gender of Lead Author**	**Nationality of Lead Author**	**Publishers** (name, city)	**Available from** (e.g.weblink or publisher if not available online)
Gravimetric sorting to improve germination of *Anogeissus leiocarpa* seed lots	Journal article	Sanogo, S., Sacande, M. and Van Damme, P. 2015	M	Malian	Seed Science and Technology Vol: 43, 318-323	http://www.ingentaconnect.com/content/ista/sst
Essais de germination et conservation de fruits et graines de quelques espèces ligneuses à usages multiples au Mali	PhD thesis	Sanogo, S. 2015	M	Malian	University of Ghent, Belgium	University of Ghent, Belgium

Annex 6 Darwin Contacts

Ref No	2367
Project Title	Pesticide plants for organic cotton, livelihoods and biodiversity in Mali
Project Leader Details	
Name	Dr Paul Wilkin, Head of Natural Capital & Plant Health Department
Role within Darwin Project	Principal Investigator (PI)
Address	Royal Botanic Gardens, Kew
Phone	
Fax/Skype	
Email	
Partner 1	
Name	Dr Sidi Sanogo
Organisation	Institut d'Economie Rurale (IER) / CRRA - Sikasso
Role within Darwin Project	Coordinateur national, supervision execution activités du projet
Address	
Fax/Skype	
Email	
Partner 2	
Name	Prof. Rokia Sanogo
Organisation	Département Médecine Traditionnelle (DMT) de l'Institut National de Recherche en Santé Publique (INRSP) - Mali
Role within Darwin Project	Etude composition chimique et toxicité des plantes pesticides
Address	
Fax/Skype	
Email	
Partner 3	
Name	Toumani Sidibé
Organisation	Fédération Nationale des Producteurs de L'Agriculture Biologique et Équitable du Mali (FENABE-Mali)
Role within Darwin Project	Coordination des activités collaboratives, supervision et animation des cooperatives paysannes
Address	
Fax/Skype	
Email	