Darwin Initiative Main Project Annual Report

Important note: *To be completed with reference to the Reporting Guidance Notes for Project Leaders: it is expected that this report will be no more than 10 pages in length, excluding annexes*

Submission Deadline: 30th April 2017

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" (DMT) ; Natural Resources Institute (UK)
Darwin grant value	£258, 540
Start/end dates of project	01/04/2014-30/09/2017 (with no cost extension agreed by DEFRA)
Reporting period (e.g., Apr 2016 – Mar 2017) and number (e.g., Annual Report 1, 2, 3)	April 2016-March 2017, Y3/Annual Report 3
Project Leader name	Dr. Paul Wilkin
Project website/blog/Twitter	http://www.kew.org/science-conservation/research-data/science-directory/projects/pesticide-plants-organic-cotton-mali, https://www.facebook.com/darwinmalicotton/, https://twitter.com/eligmocarpus/status/745927354548166658
Report author(s) and date	Paul Wilkin, Stephane Riviere, Sidi Sanogo 5/5/17

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 five 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, Mali's National Cotton Board /Department of Agriculture/Department of Forestry).

Project activity is based in four regions of southwestern Mali: Kayes, Koulikoro (surrounding Bamako Capital District), Sikasso and Segou (see map below). IER is based in Sikasso, MOBIOM in Bougouni (indicated)

2. Project partnerships

The principal partner in Mali is IER, the national agricultural research institution, which hosts Mali's Forestry Research Programme located at the regional centre of Sikasso. It has worked with Kew to study the diversity of and conserve the Malian flora for over 10 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 institutional capacity of the authorities 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 mechanism for the demand in mali for the project and its outputs to be imparted to RBG, Kew. The lead contact in IER for this project 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 partnership between Kew and IER has been stabilised in Y3 through regular communication between Dr. Sidi Sanogo (Head of the IER Forestry Seeds Herbarium Unit and the Regional Centre for Agricultural Research in Sikasso, Mali) and the project officer Stephane Rivere. It should be noted that activity in Mali is now wholly under the management of IER with progress then reported to Kew; direct participation by Kew staff has not been possible due to ongoing insurance issues caused by the terrorist threat in Mali.

The project's partnership with Mouvement Biologique Malien (MOBIOM) is managed wholly through IER. It is underpinned by an initial agreement that was established in Y1 and defines the activities that will be carried out every year by each Partner.

The partnership with the Natural Resources Institute (NRI), University of Greenwich was underpinned by Prof. Phil Stevenson's joint appointment at RBG, Kew and that Institute. This remains the case and strengthens his ability to provide scientific evidence underpinning the use of key ecosystem services, such as the validation of plant-based pesticides via bioassays 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. He has also used his NRI role to plan and staff the workshop in Tamale scheduled for June 2016 (see below).

During Y2 and 3 of the project an additional partnership has been consolidated, between IER and DMT (Département de Médecine Traditionnelle de l'Université de Bamako). DMT have undertaken toxicity tests in pesticidal plants and investigated their phytochemical composition in addition to work done by Prof. Stevenson's team (see Activity 2.2). Dr. Tiziana Ulian of RBG, Kew collaborates with Prof. Rokia Sanogo at DMT. Her team have become additionally involved in the project through the deployment of previous work on useful plants with pesticidal uses under the UPP project and seed germination testing that was to be undertaken by the former PI

3. Project progress

3.1 Progress in carrying out project Activities

Output 1. Identification and authentication of pesticide species currently used by organic cotton farmers in target communities (Output 1)

Activity 1.1. Field trips and collection of pesticidal species specimens (known scientific and local names, seeds, herbarium specimens and photographs) and vegetation survey:

Individual interviews with producers have taken place to gather information on plant and crop protection in Y3. Four botanical surveys were carried out during the months of July and September 2016 for the determination of pesticidal plants and the location of the seed plots (see Activity 1.2).

In Mali during Y2 and 3 there has been incremental compilation of information and communities' know-how on pesticide plants used by organic cotton growers and other organic crops producers in the areas of Bougouni, Yanfolila, Kolondiéba and Bla. Accumulated data on 25 pesticidal species are available in the database. 9 further species have been added into the list of pesticidal species following the Y3 interviews and surveys with producers: *Chrysopogon zizanioides, Acacia nilotica, Cordyla pinnata, Rauvolfia vomitoria, Trichilia emetica, Vernonia amygdalina, Indigofera tinctoria, Striga sp.* and *Ximenia americana* (see Activity 1.3).

Activity 1.2. Verification research on collected specimens at Kew Herbarium and MSB:

Four botanical surveys and seed and herbarium collection were carried out by the Forestry research team in Y3. The authentication of the pesticidal plants which were harvested was carried out by the USHF laboratory of Sikasso using available floras and databases.

Seeds and herbarium specimens of 15 species were collected: *Bobgunnia madagascariensis, Khaya senegalensis, Securidaca longepedunculata, Chamaechrista nigricans, Hyptis spicigera, Hyptis suaveolensis, Opilia celtidifolia, Balanites aegyptiaca, Carapa procera, Ximenia americana, Nicotiana tabacum, Lannea microcarpa, Azadirachta indica, Zanthoxylum zanthoxyloides* and *Ocimum basilicum.*

Seeds of 10 species have been conserved in the laboratory of USFH – Sikasso. The remaining 5 are recalcitrant. Viability testing of the conserved seed has been conducted at the USFH laboratory.

Activity 1.3. Compilation of data from Kew and other databases, regarding candidate species seed collecting, handling, germination and propagation. Preparation of species pages (including field photographs).

All available information on the harvested pesticidal plant species has continued to be entered into the database described in the Y1 report. Data entry has taken place across 25 species and includes local preparation methods for pesticide extracts, farmers' dosages and frequency of use of these bio-pesticides in addition to taxonomic and distribution data. In particular, germination and viability testing data has been added in Y3. Data on 9 further species (listed in Activity 1.1) have been added into the list of pesticidal species following the Y3 interviews and surveys with producers.

2. Active compounds / ingredients in the key pesticidal plants being used by cotton producers are identified and relative effectiveness of different species established (Output 2)

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 Mali, pesticide plant samples were collected by the Seed Unit team and the Entomology laboratory, and then prepared and sent to Kew during the months of September and December 2016 for phytochemical analyses (see table below).

N°	Species	Quantity	Harvested part
1	*Euphorbia paganorum*	500 g	Dried branches
2	*Bobgunnia madagascariensis*	500 g	Dried leaves
3	*Khaya senegalensis*	2,000 g	Trunk bark
4	*Securidaca longepedunculata*	500 g	Root bark

5	*Chamaechrista nigricans*	700 g	Dried leaves
6	*Hyptis suaveolens*	500 g	Dried leaves
7	*Opilia celtidifolia*	500 g	Dried leaves
8	*Balanites aegyptiaca*	70 cl	Seed oil

This will complement the tests carried out in Mali by the "Département de la Médecine Traditionnelle" (DMT) (table of samples and extracts of pesticide plants studied in the laboratory of DMT in Mali below).

N°	**Species**	**Harvested part**
1	*Balanites aegyptiaca*	Oil
2	*Chamaechrista nigricans*	Dried branches
3	*Carapa procera*	Leaves and oil
4	*Euphorbia paganorum*	Dried branches
5	*Hyptis suaveolens*	Leaves
6	*Khaya senegalensis*	Trunk bark

Activity 2.2. New bioassays 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

a. Characterisation of chemical compounds in Mali

In April 2016, research was undertaken on the main chemical constituents. They are very diverse and include terpenic compounds, limonoids of Meliaceae which are known for their insecticidal properties. The methanolic extracts of the extracts of the leafy branches *Cassia nigricans*, the leaves of *Carapa procera* and the bark of *Khaya senegalensis* are the richest in anti-radical active ingredients, which is in favour of the antioxidant properties having the capacity to protect users against molecules of poisonous preparations. The principal chemical constituents of the various organs of plants are shown in the tables and chromatograms of the figures given in Annex 4.

In May 2016, preliminary analyses of oils of *Carapa procera* and *Balanites aegyptiaca* showed the acidity indices (AI) and the unsaponifiable levels of the oils of *Carapa procera* and *Balanites aegyptiaca*. They are given in the table below.

Species oil	**Acidity indices (mg/100g)**	**Unsaponifiable levels (%)**
Carapa procera	24.32	3.14
Balanites aegyptiaca	1.85	6.29

C. procera oil has a fairly high acidity (AI). The acidity index is an amount that determines the number of free fatty acids in an oil of vegetable origin. The acid number corresponds to the amount of potash in mg necessary to neutralize the free acidity contained in 1g of fat. Generally, fats contain very little free fatty acids. Under the influence of light, moisture and microorganisms, the free acid content of the fatty substances increases with time. Hence the number of fatty acids can be considered to be a good indicator of age and the consistency of fatty substances and oils. Compared to *B. aegyptiaca* oil, which has a fairly low AI, it can be concluded that the *C. procera* oil sample was more influenced by the factors mentioned above. The unsaponifiable content of the *C. procera* oil is 3.14%.

In March 2017, DMT reported on the chemical contents of pesticidal plants in the report "Determination of the content of insecticidal active ingredients".

We determined the concentrations of insecticidal active ingredient preparations according to different solvents (mg / ml). For each sample, we selected the organ believed to contain the highest level of insecticidal compounds. For *Cassia nigricans* and *Carapa procera* most constituents are soluble in ethanol and chloroform. For *Euphorbia paganorum*, most constituents are soluble in dichloromethane, chloroform, ethyl acetate and ethanol. For *Hyptis suaveolens* most constituents are soluble in dichloromethane, chloroform and ethyl acetate. For *Khaya senegalensis* most constituents are soluble in ethanol. The insecticidal principles of Meliaceae are mainly limonoids; for *Cassia nigricans*, they are mostly Anthraquinones; for *Hyptis suaveolens*, they are mostly terpenic compounds. For *Euphorbia paganorum*, they are still to be determined. Concentration (mg/ml and expressed as a percentage) in organs of different species and their extraction method is available in Annex 5.

b. Bioassay work

At Kew, the following activities took place:

Collection and extraction of plant materials: The plant material was thoroughly washed with tap water and stored at room temperature (23.0±2.0) °C before extraction. Plant crude extracts were prepared by boiling 500mg of fresh plant material in 5ml of distilled H2O for 20 minutes. The mixtures were then allowed to cool, and sit undisturbed for 48hrs for further extraction. The crude extracts were then centrifuged to remove plant debris and transferred to clean vial for storage in the freezer at -12°C, until required for the subsequent bioassay against *Helicoverpa armigera*.

Rearing of test insects: Larvae of *H. armigera* were reared at The Royal Botanic Gardens, Kew, and were kept at 27±2°C at ambient humidity, with a photoperiod of L:D 15:9 hours. The insects were raised in isolated in transparent plastic pots from the 2nd instar onwards, with *ad libitum* access to a chickpea-based diet.

Pesticidal activity: Eighty 5th instar larvae were selected using a reference weight of approximately 125mg. Larvae were treated with 10µl of extract, placed directly onto the dorsal cuticle while avoiding the head to prevent ingestion. Insects were returned to their individual culture pots and checked after 72h for mortality, and re-weighed. The control groups were handled similarly, and treated with either H2O (-ive), acetone (-ive), or 1000ppm rotenone dissolved in acetone (+ive). Observations of mortality were made after 72hrs.

Bioassays:
Insects: Insects are reared in isolation from the 2nd instar onwards, with *ad libitum* access to chickpea-based diet. Insects can be selected based upon size. I would suggest sticking to a range between 125 and 250mg and using this as your reference point for 5th instars. Once you have carried out enough experiments then it will be possible age the insects by sight. Handle the insects as little as possible and gently to minimise stress. Coiling-behaviour, where the insects turn and bite the forceps indicates that they are being squeezed too tightly. One step up from this is regurgitation, and I would reject insects showing this response.

Extracts: 10% w/v in water. Two formulations, in water, based upon those used in the field, but without oils.

Method: Remove the insect from its culture-pot and pipette 10µL of extract on to the dorsal cuticle. For contact-only experiments ensure that the liquid does not contact the head and mouthparts, as it could then be ingested. You could argue that it does not matter, as long as the insect dies, but the amount ingested would be unquantifiable. Return the insects to their culture-pots and check daily for mortality and re-weigh after 72h. The positive control would be 100ppm rotenone in water, the negative control would be water.

Modifications: Volume applied: can be increased or the insect could be dipped quickly in the extract. Age of larvae: >90% of damage due to larvae occurs after the 3rd instar. By this time it is likely the insects would be established in the cotton boll. In general an extract that is toxic to older larvae would also be toxic to young larvae. 1st and 2nd instars can drown in quite low volumes of solvents and it is difficult to establish the route into the insect as the body-size is so small.

Results: No mortalities were observed at 72hrs after contact with extracts. This included the 1000ppm rotenone positive control, which we would expect to be biologically active and to have caused mortality. Furthermore, the mass of all insects tested with the treatments increased by between 242%-316%, similar to the negative controls (table below).

Plant Species	Mass (mg) (Day 0)	Mass (mg) (Day 3)	% Mass Change	Mortality
Balanites aegyptiaca	203	598	294%	0
Khaya senegalensis	178	503	284%	0
Carapa procera	172	542	316%	0
Euphorbia panagorum	182	477	262%	0
Bobgunnia madagascariensis	176	425	242%	0
+ve Control Rotenone in Acetone	140	433	310%	0
-ve Control Water	153	462	302%	0
-ve Control Acetone	153	432	282%	0

Further Work: the positive control failing to cause mortality suggests that 5th-instar larvae are too large to be susceptible to the application selected. The method will be modified to select and test against younger (and therefore smaller) larvae for susceptibility. Typically older stadium larvae are less susceptible to entomotoxic materials and this is the case of biological pesticides or synthetic chemical pesticides.

In Mali, a report on the study of 6 samples was produced: oil of *Balanites aegyptiaca*, leafy branches of *Chamaechrista nigricans*, leaves and oil of *Carapa procera*, leafy branches of *Euphorbia paganorum*, leaves of *Hyptis suaveolens* and bark of *Khaya senegalensis*. The oils were used as extracted and the other fresh organs were crushed and used to prepare aqueous solutions according to the traditional method of use by the producers.Then estimation of acute toxicity was undertaken. For the estimation of toxicity, extracts have been prepared as above and the toxicity was estimated on laboratory mice.

Results: under the experimental conditions, *Balanites aegyptiaca* seed oil, 20% extemporaneous extracts of *Chamaechrista nigricans* leaves, *Carapa procera* leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*, at a dose of 20ml / kg, showed no toxic effects after 14 days of observation or death of the animals. Toxic doses would therefore be higher than the doses tested. For the seed oil of *Carapa procera*, administered at a dose of 20ml / kg, the death of one of three of the mice tested was recorded after 24 h. According to the principle of the test, we must retest with a lower dose in order to discover the lethal dose. Details of the results for each batch processed are given in Annex 6.

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

In Mali, tests on the efficacy of biopesticide products were started in July 2016 among 10 producers of organic cotton in Yanfolila and Kolondiéba in order to retest the results obtained in 2015.

The study was conducted from July to November 2016. The species and formulations used were the same as those of the previous year, i.e.:

- Old formulation: Seed extracts of *Azadirachta indica* + *Carapa procera* oil
- New formulation (1): Stem extracts of *Euphorbia paganorum* + stem bark extracts of *Khaya senegalensis* + *Carapa procera* oil
- New formulation (2): Plant extracts of *Chamaecrista nigricans* + stem extracts of *Euphorbia paganorum* + *Balanites aegyptiaca* oil.

Note: the new formulation (1) was used in Yanfolila and (2) in Kolondiéba, whereas the old formulation served as a control in the two study areas.

The results obtained using these two formulations are listed in table below (Seed cotton output of 2016 production: efficacy test of new bio-pesticide formulations compared to the old one)

Zone	**Name of producer**	**Yield seed cotton Kg/ha**		
		Old Formulation	New Formulation	Difference
Kolondiéba	Solomani N°1 Koné	687.5	937.5	250
	Oussoumani Koné	562.5	750	187.5
	Guedjouma Koné	843.75	937.5	93.75
	Solomani Koné	812.5	1062.5	250
	Chaka Koné	*	*	
Yanfolila	Oumar Timbiné	662.5	700	37.5
	Awa Timbiné	575	750	175
	Fousseni Fongoro	518.75	593.75	75
	Mariam Fongoro	450	687.5	237.5
	Alima Fongoro	406.25	562.5	156.25

* Note: Chaka Koné's data were rejected due to non-compliance with organic production standards.

An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and Yanfolila compared to the old formulation used by organic cotton producers. The efficacy test should be repeated on all four study areas. Y2 yields were increased by 23 and 22 % respectively. This sustained and additional increase adds weight supports the hypothesis that project activity is the root cause and not random or seasonal events, although of course a broader study and more rigorous analysis is desirable.

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

The project and its outputs will be presented at the AETFAT conference in Nairobi on Wednesday 17th May 2017 (please see programme in Annex 7).

3 Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers (Output 3)

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

A programme of basic training was conducted in Mali on 1) oil extraction techniques in *Balanites aegyptiaca* and *Carapa procera.2)* preparation and use of biopesticides 3) identification and recognition of pests and other pests of cotton. More detailed training took place in 1) October 2016, 2 village community workers of Ifola on techniques of extraction of oil of *Balanites aegyptiaca 2)* January 2017: training of women in Ziekorodougou on oil extraction techniques of *Carapa procera* (please see photos in Annex 8) 3) July 2016: training of 10 producers (7 men, 3 women) on tests of efficacy of biopesticides and the preparation and use of products 4) July 2016: training of 12 producers (9 men, 3 women) on identification and

recognition of cotton pests (please see photos in Annex 9). 5) Training of women of Ziékorodougou allowed a comparative study of the farmers' practice and that practiced by USFH technicians in the production of oil of *Carapa procera*. For the farmers' technique, *C. procera* nuts are fermented by keeping them underground for 6 months (please see photos in Annex 10).

Thus two women-only training events were undertaken and of those training events that were enumerated, the % of women was 27%.

Two training sessions will be conducted in June 2017 during the harvest period of the fruit of *Carapa procera.*

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

Following the project GANTT chart, this activity will be carried out during the second quarter of 2017 with the close collaboration of FENABE-Mali in Tamale in northern Ghana for security reasons. This will be reported in the final report.

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

Following the project GANTT chart, this activity will be carried out during the second quarter of 2017 by FENABE-Mali in country.

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

FENABE will undertake development of local markets and industrial investment to promote the use of project organic pesticides April-September 2017.

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 (Output 4)

Activity 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)

Demonstration plots set up in communities in 2014 and 2015 were monitored and maintained. Plots were replenished in August 2016 (see Annex 11), and the quantity of plants used to replenish them 2016 is shown in Annex 12. Due to their proximity to dwellings, 2 plots in the Bla area were protected with a wire fence to exclude grazing animals.

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

In Mali, the activities were carried out in two areas: 1) study on the physiology of germination of seeds of pesticidal plants 2) training of nurserymen and production of seedlings in village nurseries. In 1) Six trainees (2 technical Masters degree level, 1 Undergraduate degree, 3 Technical degree studied the germination physiology of pesticidal and food species. Species were *Lannea microcarpa, Ximenia americana, Strichnos spinosa, Zanthoxylum zanthoxyloides* and *Euphorbia paganorum* (cuttings) (see title and contents pages of 2 theses in Annex 13). Tests on seed germination physiology are underway with other pesticidal plant species. The tests will be carried out over the next six months (April - September 2017). In 2) Two village nurseries were provided with inputs and nursery materials in the village of Niala (Bla). Four village nurserymen were trained on seed harvesting and pre-treatment techniques. The

quantity of plants produced per nursery is shown in Annex 14. Tests on nursery production techniques will be carried out with three (3) students (2 Undergraduate degree, 1 Technical degree) from June to September 2017.

At Kew, literature reviews of targeted species has been carried out. Germination tests have been delayed to Q5 (April-June 2017) due to (i) delay in recruiting the research assistant responsible for the germination tests and (ii) delay in importing seed material into Kew-MSB from Mali. The literature review is shown in Annex 15.

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.

In Mali, plantations are located in 14 farms, with 6 plant species are planted on 8.75 ha: *Adansonia digitata, Khaya senegalensis, Carapa procera, Tamarindus indica, Faidherbia albida, Parkia biglobosa.* Biophysical assessment of the demonstration plantations was carried out in November 2016 (height, collar diameter, plant survival rate) (see Annex 16). Monthly monitoring of demonstration plots was carried out by the Forest Service of Bla and Bougouni. Further biophysical assessments will be conducted in June and November 2017

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

A training workshop will be held in Tamale in June 2017, Ghana on the preparation and use of biopesticides. A total of 25 participants will attend the workshop (19 from Mali, 3 from Benin OBEPAB and 3 from RBG-Kew) (please see details in Annex 17). Once back in country, the attendees will organise dissemination workshops to the wider organic cotton farming community in Mali.

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

A radio program in Bambara was produced during Y3 on the benefits of the use of biological pesticides in the four project areas.

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

The book Guide d'identification des Arbres du Mali (Sacande, M, Sanogo S and Beentje H) was published by Kew Publishing in May 2016 (see http://shop.kew.org/guide-d-identification-des-arbres-du-mali).

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) (Output 5)

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

A restitution workshop was organized at FENABE-Mali in July 2016, at which the results of the campaign were returned to farmers and technical services (Agriculture, Forestry/Environment, "Compagnie Malienne de Développement des Textiles (CMDT)", FENABE-Mali). Title slide of presentation by Dr. Sidi Sanogo in Annex 13.

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

In Mali, a workshop on the restitution of results will be held in July 2017. This workshop will be a forum to disseminate results on pesticidal plants.

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.

After the Tamale workshop in June 2017, another training workshop will be held in Mali to disseminate results to the wider organic cotton farming community in Mali.

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

This will be carried out by IER consultants in April to September 2017.

6. Assessment of potential climate risks that may impact pesticidal species. (Output 6)

Activity 6.1- Assessment of potential climate risks for important pesticide-plant for organic cotton production.

A study will be carried out by a team of the Program of Production and Natural Resources Management System of IER Sikasso in Q5 and Q6 via 2 consultants hired by IER. The questionnaire and interview guide are being developed.

3.2 Progress towards project Outputs

Output 1:	Identification and authentication of pesticide species currently used by organic cotton farmers in target communities.			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 1.1	No list of pesticide plants at start of project	Base list established from desk study and questionnaires in the 4 regions of Mali	List of 25 species (see Annex 18). 9 further species added in Y3 – see Activity 1.1	
Indicator 1.2	No specimens of seeds and herbarium vouchers of pesticide plants collected at start of project.	Seeds and herbarium specimens of 15 species were collected and conserved in Y3	MSB database	
Indicator 1.3	No list of authenticated pesticide species at start of project.	The list of 25 authenticated pesticide species plus data from bioassays and	Mali IER database	

		field experiments, plus 9 new species added.		

Output 2:	*Active compounds / ingredients in the key pesticidal plants being used by cotton producers are identified and relative effectiveness of different species established*			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 2.1	No identified components at start of project	Chemical constituents of organs of the insecticidal species generated	Report from Prof. Rokia (DMT) is available in Annex 4	
Indicator 2.2	No knowledge of relative effectiveness of different species at start of project.	In Mali: multiple extracts at a dose of 20ml / kg, showed no toxic effects after 14 days of observation. For *Carapa procera* oil 20ml / kg, the death of a mouse was recorded after 24 h. At Kew, no mortalities were observed at 72hrs after contact with extracts in 5th instar Helicoverpa	DMT Report in Annex 6	Biopesticides need to be used against earlier instars to be effective
Indicator 2.3	No understanding of relative effectiveness and dosages of different species	An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and Yanfolila in Y3 compared to the old formulation used by organic cotton producers. 23 and 22 % in Y2.	Yield seed cotton Kg/ha provided	Broader study and more rigorous analysis is desirable but supports idea increase is due to project activity

Output 3:	*Four small-scale organic pesticide producers established and trained to supply optimum standard organic pesticides to cotton farmers.*			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 3.1	No farmers/small scale producers trained at start of project	October 2016: training of 2 village community workers from Ifola	Annex 8	

		on techniques of extraction of oil of *Balanites aegyptiaca* January 2017: training of women in Ziekorodougou on oil extraction techniques of *Carapa procera*		
Indicator 3.2	No small scale supply branches of standardised pesticide products at start of project	Two cooperatives (Samaguéla and Ziékorodougou) were equipped for oil production. A system of production/supply has been established by individuals using facilities for oil extraction	Annex 8	
Indicator 3.3	No market niche for plant products at start of project.	Development of local markets and industrial investment to promote the use of elaborated organic pesticides still to be carried out by FENABE	N/A	

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*			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 4.1	No demonstration gardens at start of project. 6.5 Ha of planting in Y1	11 hectares were planted in both 2014 and 2015 across 19 farms replenished in August 2016 (total of 4,905 seedlings used). Monitoring and maintenance in Y3.	Annex 14	
Indicator 4.2	Unknown but limited seed collection and seedling production at start of project	A total of 34,430 seedlings of 7 species for the demonstration plots and members of	Annex 14	

		organic cotton producers' cooperatives in the Bla area. Seed sourced from within Mali at a sufficient level.		
Indicator 4.3	No data	Biophysical assessments will be conducted in April and October 2017 (Q5 and Q6)	Annex 16	

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	Limited awareness; project guidelines awaited.	The campaign results of the pesticide project were presented two working meetings will be held with the CMDT, Agriculture and the Chamber of Agriculture, Helvetas-Switzerland Intercooperation on organic production certification		
Indicator 5.2	CMDT not using community garden approach	CMDT has not yet developed community gardens		
Indicator 5.3		CMDT and the Departments have discussed with stakeholders such as Helvetas, which means that a process and a methodology are in place		

Output 6:	*Analysis of climatic data and climate change mitigation plan*			Comments (if necessary)
	Baseline	Change recorded by 2017	Source of evidence	
Indicator 6.1	No analysis of	Questionnaire		

	climate data and climate change mitigation plan at start of project	and interview guide are being developed by IER consultants		

3.3 Progress towards the project Outcome

Outcome: The sustainable use and cultivation of pesticidal plants for organic cotton production leads to increased income generation among target communities, and reduces the loss of plant biodiversity in southern Mali.

Outcome:	Paste here 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.			Comments (if necessary)
	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 in Y1	4 community gardens established, 11 Ha in Y2 monitored and maintained in Y3	Details of the structure of the cooperatives and the planted area are available in Annex 19	
Indicator 2 Important pesticide species show marked reduction* in losses, benefitting the conservation of wild populations **(Indicator to be made SMART following the identification and authentication of exact pesticidal species being used – see Output 1)*	Y1 vegetation survey did not take place due to a failure of management by the previous PI	During the final months of the project, IER will survey the species harvested exclusively from the wild *in situ* and ask farmers if they have a changed their habits with regard to the way they collect the plants. This will answer the question "Do the cultivated plants supply the demand?"		
Indicator 3 Yields of 'first class' organic cotton increase by 5% across target	CMDT historical yield data	An improved yield of seed cotton of 27% and 26% was observed	Annex 20	

communities, increasing farmers' revenues and securing crop bonuses for reaching organic cotton production targets by Y3 *(These targets are set by the national cotton processor. Through FENABE the money is typically invested into community infrastructure projects such as schools or health clinics)*		respectively in Kolondiéba and Yanfolila compared to the old pesticidal formulation used by organic cotton producers. See also section 3.5		
Indicator 4 All beneficiary women farmers (30% of FENABE) have increased their income by 10 to 25% in the four regions by Y3	Socio-economic survey carried out at the beginning of project	Yield increases as indicator 3 but gender-related data not available		
Indicator 5 >25% of cotton farmers in target communities use optimum standard organic pesticide and treatment regimes, reducing wastage by Y3	Socio-economic survey carried out at the beginning of project	No new data in Y3 but socioeconomic surveys will be repeated by September 2017 and will capture this information.		

3.4 Monitoring of assumptions

Assumption 1: Unaltered

Assumption 2: The 4 small-scale producers of organic pesticide can continue to source raw material needed to create the optimal pesticide for organic cotton farmers.

Comments: 1) It has been reported by cotton producers that the age of many *Carapa* trees has caused problems with fruit production. However, the Y3 level of production of *Carapa procera* oil in Mali has meant FENABE not to have to source extra oil from Guinea. Thus the problem is being managed 2) the area from which of *Balanites aegyptiaca* and *Euphorbia paganorum* are sourced is distant from the oil production units. The partner organisations in Mali do not believe that this will directly impact the project's outcome or impact.

Assumption 3: The national cotton board (CMDT) maintains its support to organic cotton production and its marketing.

Comments: CMDT's support has been maintained up to Y3

Assumption 4: Climatic variation does not threaten the viability of pesticide plant cultivation in community gardens.

Comments: A study will be carried out by a team of the Program of Production and Natural Resources Management System of IER Sikasso in Q5 and Q6 (April-September 2017).

Assumption 5: International organic cotton prices do not fall significantly.

Comments: Regardless of the international organic cotton price fluctuation, the Compagnie Malienne pour le Développement des Textiles (CMDT) buys cotton from producers "in advance". So if prices fall too much and that the resale price does not cover the production cost, a "Union of Producers" which holds 60 % of sales revenues (CMDT 40%) refund the difference, thanks to a specifically provided funds for this kind of situations. The "advance" purchasing system implemented by CMDT guarantees the Malian producer against the volatility of world prices. Therefore the risk exists, but the producer is not directly affected. Indeed, this "support fund" which is made with the revenues earned during the good years – i.e. of the 60 % of annual revenue accruing to producers a percentage is taken to supply this fund - can limit this kind of risk to the cotton producer (See: http://maliactu.info/economie/compagnie-malienne-pour-le-developpement-des-textiles-qui-veut-destabiliser-la-filiere-coton). This remains the case in Y3.

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

An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and Yanfolila compared to the old formulation used by organic cotton producers, leading to improved livelihoods. Y2 yields were only up by 23 and 22 % respectively. This has both an immediate livelihood benefit in those two communities and a potential longer term impact for the 10, 500 farmers of the 85 cooperatives under the FENABE umbrella in the four regions of southern/southwestern Mali. The family members of those farmers total over 100, 000 people who will benefit indirectly.

In Mali, IER are plan in April-September 2017 to a) survey the species harvested exclusively from the wild in situ and b) survey farmers to discover if they have a changed their habits with regard to the way they collect the plants. This will address the question "do the cultivated pesticidal plants supply the demand?

4. Contribution to the Global Goals for Sustainable Development (SDGs)

The project's contributions to the SDGs are to SDG 1 (End poverty), SDG 2 (Promote sustainable agriculture), SDG5 (Gender equality) and SDG15 (Sustainable use of terrestrial ecosystems/reduce desertification/land degradation/biodiversity loss). SDG 1 is supported by further improvements to yields of seed cotton in Kolondiéba and Yanfolila compared to when the old pesticidal formulation is used, and the potential for the improvements to be rolled out to other communities and cooperatives. SDG 2 is promoted by the use of biopesticide as opposed to commercial pesticide formulations and the overall project contribution towards longer term sustainable cotton production in Mali. Gender equality is supported by the training of women in organic cotton cultivation techniques, overall yield improvement and will also be supported by the transfer of information and knowledge to Mali from the workshop in Tamale. The project aims to reduce unsustainable use of wild pesticidal plant resources (SDG 15) via cultivation. The final survey of farmers will clarify if practices have changed towards sustainability.

5. Project support to the Conventions, Treaties or Agreements

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

- Raising awareness of the values of (plant) biodiversity and the steps needed to conserve and use it sustainably (Aichi Target 1). Progress has been made towards this target in the first year through the questionnaires and discussion with local stakeholders.
- 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 has been limited severely by travel restrictions due to Ebola in Y1 and terrorist activity/associated insurance-based issues in Y2/3 such that and only IER project staff have been able to make such contact. Activity in country has contributed to all of the above except bullets 2 and 8, as evidenced by other sections and Annexes of this report.

6. Project support to poverty alleviation

The expected direct beneficiaries of the project are the 10, 500 farmers of the 85 FENABE cooperatives in the four regions of southern/southwestern Mali. The family members of those farmers total over 100, 000 people who will benefit indirectly. In Y3 the most promising indicators that income will be positively impacted continue to be the increased yields with new pesticidal formulations in Yanfolila and Kolondiéba and the sale and production of *Carapa procera* oil, which has again enabled FENABE not to have to source extra oil from Guinea, despite issues with an aging profile of trees in the 4 regions.

7. Project support to gender equality issues

Gender equality is supported by the training of women in organic cotton cultivation techniques (see Activity 3.1/Annex 8), including training of women in Ziekorodougou on oil extraction techniques of *Carapa procera.* It will also be supported by the transfer of information and knowledge to Mali from the workshop in Tamale in July to women. Overall yield improvement also bebefits women (see section 3.5) Women constitute 3, 150 of the 10, 500 farmers of FENABE.

8. Monitoring and evaluation

Problems in communication and travel have continued to hamper M & E efforts during Y3 following the two week visit of IER personnel to RBG Kew in terms of the lead organisation's role in Y2. Community participatory M & E in Mali has continued via IER working with FENABE both in its headquarters and on farms. The socioeconomic and farmer survey work to be undertaken in April-September 2017 will provide much of the necessary evidence for M & E. In effect, the lead organisation has acted to monitor and reviewed the work of IER work in Mali during Y3. This process enabled the generation of an effective and realistic new logframe and budget via the change request agreed in December 2016.

9. Lessons learnt

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 produced some results on the effectiveness of extracts and compounds from those species against pests.

The project has faced multiple challenges, from the field to the laboratory. In Mali, demonstration plots need careful monitoring and protection because of water shortages and animal encroachments; some have been fenced. In the laboratory, the initial new batch of

Helicoverpa brought to Kew failed to grow and undergo reproduction due to quality and transport problems; new individuals had to be sourced from the supplier.

The workshop scheduled for June 2017 in Tamale that 19 participants from Mali and 3 Benin (NGO OBEPAB “Organisation Béninoise pour la Promotion de l'Agriculture Biologique”) will attend will be critical to inform the wider Malian organic cotton farming community about sustainable use of pesticidal plants and their cultivation via cascading information from the participants within Mali.

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

We thank the DI and its reviewer for the Y2 report. We have attempted to provide evidence of progress as far as possible during this review, have reviewed the output assumptions, and sought to provide clearer information on progress against the outcome within the constraints of communication with IER. Other comments and queries raised in the Y2 report have been addressed, including the status of the Y1 vegetation survey, the impact of *Carapa procera* age on oil production and hence the project and the impact of distance of project areas from populations of *Balanites aegyptiaca* and *Euphorbia paganorum*. Further increases in cotton production support the principle that project methods underpin the recorded increases.The DI logo has been used more extensively (see Annex 13) and we will ensure that the final socioeconomic and farmer surveys are carried out before the project closes in September 2017. Finally, output 6 (Analysis of climatic data and climate change mitigation plan) was added via the change request following the recommendation of the reviewer. We would have liked to involve Kew staff in this activity but once again travel restrictions meant it had to be undertaken by IER alone.

11. Other comments on progress not covered elsewhere

The significant difficulties encountered by the project (ebola, terrorism in Mali and Burkina leading to travel restrictions for UK project personnel and visa acquisition difficulties for Malians, PI change) that were pre-project risks have continued to be problematic in Y3 but have been managed and mitigated to bring project towards as successful a conclusion as possible in terms of the outputs and outcome. Unlike the Y2 report, this one was written through remote access only (phone, skype and email) with Dr. Sidi at IER.

12. Sustainability and legacy

The initial strategy to deliver sustainability and legacy via IER and its ability to influence the national governmental Forestry and Agriculture Departments within Mali still stands. We also intend to link the final phases of the project to a second RBG Kew project, the Mali component of the Useful Plants Project (UPP). This is currently in its final dissemination phase, and we will feed back Mali Cotton project use data and its validation to the communities of back to community via UPP. UPP provided the original support and basis for this project, and the link to the first in-country farmers’ group. UPP Mali information will be fed back to stakeholders in this project via the June 2017 workshop in Tamale. The partnership described above with DMT in Banako and its departmental head Dr. Rokia Sanogo has consolidated collaboration with IER, promoting in country research and providing a link to policy makers; Dr. Sanogo is highly influential with government and advises the Prime Minister.

13. Darwin identity

The DI logo can be seen on the restitution workshop presentation by Dr. Sidi and the theses by students in Annex 13 (see also Activity 4.2). The DI was acknowledged orally during other workshops in Mali and during the radio broadcast (Activity 4.5). When Drs Sidi Sanogo and Kader Sanogo visited the UK in 2016, the need to promote and publicise the DI and that it deployed UK government development funding to stakeholders and influencers in Mali was

stressed by the lead organisation. The project has a facebook page with a small number of posts and 26 likes. It is not linked to DI social media.

14. Project expenditure

Table 1: Project expenditure during the reporting period (1 April 2016 – 31 March 2017)

Project spend (indicative) since last annual report	2016/17 Grant (£)	2016/17 Total Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)			1	
Consultancy costs	0	0	0	
Overhead Costs			1	
Travel and subsistence	0	0	0	
Operating Costs			68	The following operating cost lines have had to be delayed to April-September 2017 due to IER operational issues: Study of assisted natural regeneration of pesticidal plants, production and promotion of biopesticides, local marke development, Information and communication (particularly posters and leaflets); monitoring and evaluation and programmation of activities. At Kew, the late arrival of seed has meant that germination experiments have been delayed to April-September 2017 and the conference presentation on the project will made be in May at AETFAT (*http://www.aetfat2017.museums.or.ke/*
Capital items (see below)		0	100	IER have encountered delays in setting up the 3 biopesticide production units; they will be completed in April-September 2017
Others (see below)				
TOTAL				

Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2016-2017

Project summary	Measurable Indicators	Progress and Achievements April 2016 - March 2017	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) Yields increased by 26-27% in Yanfolila and Kolondiéba using new pesticide formulations. Immediate livelihood benefit in those two communities and a potential longer term impact for the 10, 500 farmers of the 85 cooperatives. 2) In Mali, IER are planning in April-September 2017 to a) survey the species harvested exclusively from the wild in situ and b) survey farmers to discover if they have a changed their habits with regard to the way they collect the plants.	[redacted]
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 increase by 5% across target communities, increasing farmers'	4 community gardens established, 11 Ha in Y2 monitored and maintained in Y3 No new data in Y3 An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and	During the final months of the project, IER will survey the species harvested exclusively from the wild *in situ* and ask farmers if they have a changed their habits with regard to the way they collect the plants. This will answer the question "Do the cultivated plants supply the demand?"

	revenues and securing crop bonuses for reaching organic cotton production targets by Y3.	Yanfolila compared to the old formulation used by organic cotton producers	
	4. All beneficiary women farmers (30% of MOBIOM) 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	Yield increases as indicator 3 but gender-related data not available	Socioeconomic surveys will be repeated by September 2017 and will capture this information
	5. >25% of cotton farmers in target communities use optimum standard organic pesticide and treatment regimes, reducing wastage by Y3	No new data in Y3 but socioeconomic surveys will be repeated by September 2017 and what captures this information.	
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 4 Regions of Mali	Base list established from desk study and questionnaires in the 4 regions of Mali	
	1.2 Collections of specimens of seeds and herbarium vouchers of pesticide species	Seeds and herbarium specimens of 15 species were collected.	
	1.3 List of pesticidal species that have been authenticated in the field and laboratory, with confirmed scientific and vernacular names	The list of 25 authenticated pesticide species plus data from bioassays and field experiments	
Activity 1.1 Field trips and collection of pesticidal species specimens (known scientific and local names, seeds, herbarium specimens and photographs) and vegetation survey:		Individual interviews with producers have taken place to gather information on plant and crop protection. Four botanical surveys were carried out during the months of July and September 2016 for the determination of pesticidal plants and the location of the seed plots. In Mali during Y2 and 3 there has been incremental compilation of information and communities' know-how on pesticide plants used by organic cotton growers and other organic crops producers in the areas of Bougouni, Yanfolila, Kolondiéba and Bla.	
Activity 1.2 Verification research on collected specimens at Kew Herbarium and MSB:		Four botanical surveys and seed and herbarium collection were carried out by the Forestry research team in Y3. The authentication of the pesticidal plants which were harvested was carried out by the USHF laboratory of Sikasso using available floras and databases. Seeds and herbarium specimens of 15 species	

		were collected.
Activity 1.3 Compilation of data from Kew and other databases, regarding candidate species seed collecting, handling, germination and propagation. Preparation of species pages (including field photographs).		All available information on the harvested pesticidal plant species has continued to be entered into the database described in the Y1 report. Data entry has taken place across 25 species and includes local preparation methods for pesticide extracts, farmers' dosages and frequency of use of these bio-pesticides in addition to taxonomic and distribution data. In particular, germination and viability testing data has been added in Y3. Data on 9 further species have been added into the list of pesticidal species following the Y3 interviews and surveys with producers.
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	Contents of the insecticidal active ingredients of the extracts expressed in quantity (mg) and percentage by in DM's report.
	2.2 Establish pesticidal efficacy of at least 6 species in laboratory conditions	In Mali: *Balanites aegyptiaca* seed oil, 20% extemporaneous extracts of *Chamaechrista nigricans* leaves, *Carapa procera* leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*, at a dose of 20ml / kg, showed no toxic effects after 14 days of observation. For *Carapa procera* oil 20ml / kg, the death of one of three of the mice tested was recorded after 24 h. At Kew, no mortalities were observed at 72hrs after contact with extracts.
	2.3 Determine dose of combined ingredients of different species in field tries	An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and Yanfolila compared to the old formulation used by organic cotton producers
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 Mali, pesticide plant samples were collected by the Seed Unit team and the Entomology laboratory, and then prepared and sent to Kew during the months of September and December 2016 for phytochemical analyses
Activity 2.2. New bio-assays and identification of chemical composition of collected specimens, carried out mainly at Kew by Paul Green		For the chemical compounds, in Mali, in April 2016, research was undertaken on the main chemical constituents. In May 2016, preliminary analyses of oils of *Carapa procera* and *Balanites aegyptiaca* showed the acidity indices (AI) and the unsaponifiable levels of the oils of *Carapa procera* and *Balanites aegyptiaca*. In March 2017, DMT reported on the chemical contents of pesticidal plants in the report "Determination of the content of insecticidal active ingredients". As for the bioassays at Kew, no mortalities were observed at 72hrs after contact with extracts. This included the 1000ppm rotenone positive control, which we would expect to be biologically active and to have caused mortality. Furthermore, the mass of all insects tested with the treatments increased by between 242%-316%, similar to the negative controls. In Mali, *Balanites aegyptiaca* seed oil, 20% extemporaneous extracts of *Chamaechrista nigricans* leaves, *Carapa procera*

		leaves, *Euphorbia paganorum* leafy branches, *Hyptis suaveolens* leaves and bark of *Khaya senegalensis*, at a dose of 20ml / kg, showed no toxic effects after 14 days of observation or death of the animals. Toxic doses would therefore be higher than the doses tested. For the seed oil of *Carapa procera*, administered at a dose of 20ml / kg, the death of one of three of the mice tested was recorded after 24 h.
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		An improved yield of seed cotton of 27% and 26% was observed respectively in Kolondiéba and Yanfolila compared to the old formulation used by organic cotton producers. The efficacy test should be repeated on all four study areas.
Activity 2.4. Present research outcomes at AETFAT conference in May 2017 (oral presentation)		The project and its outputs will be presented at the AETFAT conference in Nairobi on Wednesday 17th May 2017
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 4 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 4 Regions managed by the trained farmers as inputs 3.3 Specific market niche of pesticidal plant products identified and investments established	Training of 2 village animators of Ifola on techniques of extraction of oil of *Balanites aegyptiaca* in October 2016. Training of women in Ziekorodougou on oil extraction techniques of *Carapa procera* in January 2017. Two cooperatives (Samaguéla and Ziékorodougou) were equipped for oil production. A system of production/supply has been established by individuals using facilities for oil extraction Development of local markets and industrial investment to promote the use of elaborated organic pesticides still to be carried out by FENABE
Activity 3.1. Develop improved methods for harvesting and efficient protocols for by-product extraction that optimise bioactivity and reduce over-collection and wastage		A programme of basic training was conducted in Mali on 1) oil extraction techniques in *Balanites aegyptiaca* and *Carapa procera.2)* preparation and use of biopesticides 3) identification and recognition of pests and other pests of cotton. Two women-only training events were undertaken and of those training events that were enumerated, the % of women was 27%. Two training sessions will be conducted in June 2017 during the harvest period of the fruit of *Carapa procera.*
Activity 3.2. Training workshops for pesticidal plants producers on preparation and presentation of standardised products (at least two trainer farmers per region)		This activity will be carried out during the second quarter of 2017 with the close collaboration of FENABE-Mali in Tamale in northern Ghana for security reasons.
Activity 3.3. Develop IPR, farmers' ownership and product registration protocols for organic cotton production according to the regulations in place in Mali		This activity will be carried out during the second quarter of 2017 by FENABE-Mali in country.
Activity 3.4. Exploit local industrial investment opportunities and economic markets to promote the use of optimum standard organic pesticides, similar to the		FENABE will undertake development of local markets and industrial investment to promote the use of project organic pesticides April-September 2017.

traditional medicine model in Mali		
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 data on survival and growth of seedlings in the plots.	11 hectares were planted in both 2014 and 2015 across 19 farms replenished in August 2016 (total of 4,905 seedlings used) A total of 34,430 seedlings of 7 species for the demonstration plots and members of organic cotton producers' cooperatives in the Bla area. Seed sourced from within Mali at a sufficient level. Biophysical assessments will be conducted in April and October 2017 (Q5 and Q6)
Activity 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)		Demonstration plots set up in communities in 2014 and 2015 were monitored and maintained. Plots were replenished in August 2016.
Activity 4.2. Train, collect seeds of selected key species and produce enough seedlings in communities nurseries		In Mali, the activities were carried out in two areas: study on the physiology of germination of seeds of pesticidal plants (6 trainees) and training of nurserymen and production of seedlings in village nurseries.
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.		In Mali, plantations are located in 14 farms, with 6 plant species are planted on 8.75 ha.
Activity 4.4. Organise farmer and NGO workshops to inform the wider farming community about sustainable use of pesticidal plants and their cultivation.		A training workshop will be held in Tamale in June 2017, Ghana on the preparation and use of biopesticides.
Activity 4.5. The benefits of cultivating pesticidal plants for organic production promoted through farming fairs, exhibitions (video) and local radio.		A radio program in Bambara was produced on the benefits of the use of biological pesticides in the four project areas.
Activity 4.6. Reproduction of guide/hand book, leaflets and posters through Kew Publishing (in local language)		The book Guide d'identification des Arbres du Mali (Sacande, M, Sanogo S and Beentje H) was published by Kew Publishing in May 2016
Output 5. Increased awareness of pesticidal plant use for organic cotton	5.1 CMDT/Agriculture/Forestry use project guidelines for managing native	The campaign results of the pesticide project were presented two working meetings will be held with the CMDT, Agriculture and the Chamber of Agriculture,

production among policy makers and cotton growing communities in Mali (CMDT/Dept. of Agriculture/Dept. of Forestry)	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 résilence of farming system in rural communities' development via project final workshop in West-Africa, where Forestry agents would promote the project methodology	Helvetas-Switzerland Intercooperation on organic production certification CMDT has not developed community gardens CMDT and the Departments have discussed with stakeholders such as Helvetas, which means that a process and a methodology are in place
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		A restitution workshop was organized at FENABE-Mali: the results of the campaign were returned to farmers and technical services (Agriculture, Forestry/Environment, "Compagnie Malienne de Développement des Textiles (CMDT)", FENABE-Mali).
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		In Mali, a workshop on the restitution of results will be held in July 2017. This workshop will be a forum to disseminate results on pesticidal plants.
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.		After the Tamale workshop in June 2017, another training workshop will be held in Mali to disseminate results to the wider organic cotton farming community in Mali.
Activity 5.4. Second socioeconomic survey to be carried out in Mali by IER (overall method to measure the 5 indicators of the outcome of the project)		This will be carried out by IER consultants in April to September 2017.
Output 6. Assessment of potential climate risks that may impact pesticidal species.	6.1 Assessment of potential climate risks that may impact pesticidal species.	The questionnaire and interview guide are being developed.

Annex 2: Project's full current logframe as presented in the application form (unless changes have been agreed): Logframe as agreed following December 2016 Change Request

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 increase 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 (30% of MOBIOM) 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 woodlots by IER, MOBIOM and Kew 2. Vegetation surveys in the four regions at beginning and end of project 3. MOBIOM annual reports; Household surveys and questionnaire, and reports 4. MOBIOM annual reports; Household surveys and questionnaire, and reports 5. Household surveys and questionnaire, and technical reports	1. Plant propagation and analytical research on the target pesticide species does not prove to be exceptionally difficult. 2. The 4 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 communities	1.1 Established base list of pesticide species collated from desk study and questionnaires addressed to organic cotton farmers in the 4 Regions of Mali 1.2 Collections of specimens of seeds and herbarium vouchers of pesticide	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 important compounds and extraction methods can affect the standardisation

	species 1.3 List of pesticidal species that have been authenticated in the field and laboratory, with confirmed scientific and vernacular names		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 6 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 4 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 4 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 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 data on survival and growth of seedlings in the plots.	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 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 résilence 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)

1.2 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 socioeconomic 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 communities 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 socioeconomic 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 important pesticide-plant for organic cotton production

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

This a new output/activity that we have incorporated to take into account the reviewer's comment, as far as is possible at this stage of the project. We will assess the climate risk through a literature survey focussing on the key pesticidal species' responses to climate change and modelling-based research allied to historical climate data acquisition and predictive climate models in Mali. The potential implications for the pesticidal species will then be compiled into a report.

Annex 3: Standard Measures

Table 1 Project Standard Output Measures

Code No.	Description	Gender of people (if relevant)	Nationality of people (if relevant)	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
Established codes								
1B	Dr. Sidi Sanogo's PhD	M	Malian		1	0	1	1
2	3 s MSc students (6 months training)	M	Malian		3	2	5	5
3	Other qualifications: Technical degrees	M	Malian		0	2	2	4
4A 4B 4C 4D	Undergrad no. Training weeks Postgrad no. Training weeks				25 162.5 3 88	1 6.5 2 53	26 169 5 141	29 170 6
10	Field Guides/manuals				0	1	1	1

Table 2 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)
Guide d'Identification des Arbres du Mali	Book	Moctar Sacande, Sidi Sanogo & Henk Beentje 2016	Male	Malian	Kew Publishing	http://shop.kew.org/guide-d-identification-des-arbres-du-mali)

Annex 4 Chemical constituents analysis

1. Main chemical constituents

Table N°1: Chromatogrammes of methanol extracts diluted in MeOH : H_2O (1 :1) of samples in BAW (65 : 15: 25) (Figures N°1).

Samples	R_f of main stains
CP = *Carapa procera*	0,16 ; 0,44 ; 0,56 ; 0,65 ; 0,75 ; 0,87
CN = *Chamaechrista nigricans*	0,21 ; 0,54 ; 0,65 ; 0,71 ; 0,87
EP= *Euphorbia paganorum*	0,46 ; 0,62 ; 0,75 ; 0,87
HS= *Hyptis suaveolens*	0,75 ; 0,87
KS= Khaya senegalensis	0,04 ; 0,17 ; 0,27 ; 0,78

Table N°2: Chromatogrammes of methanol extracts diluted in MeOH : H_2O (1 :1) of samples in BAW (40 : 20: 10) (Figures N°2).

Samples	R_f of main stains
CP = *Carapa procera*	0,19 ; 0,42 ; 0,50 ; 0,58 ; 0,81
CN = *Chamaechrista nigricans*	0,22 ; 0,35 ; 0,47 ; 0,62 ; 0,75 ; 0,87
EP= *Euphorbia paganorum*	0,44 ; 0,62 ; 0,71 ; 0,87
HS= *Hyptis suaveolens*	0,75 ; 0,87
KS= Khaya senegalensis	0,06 ; 0,18 ; 0,31 ; 0,75 ; 0,90

Table N°3: Chromatogrammes of methanol extracts diluted in MeOH : H_2O (1 :1) of samples in Ethyl Acetate : MéthylEthyleCétone : Formic Acid : H_2O (50:30 :10: 10) (Figures N°3).

Samples	R_f of main stains
CP = *Carapa procera*	0,04 ; 0,457 ; 0,69 ; 0,78 ; 0,87
CN = *Chamaechrista nigricans*	0,05 ; 0,44 ; 0,56 ; 0,66 ; 0,75 ; 0,92
EP= *Euphorbia paganorum*	0,03 ; 0,15; 0,44; 0,52 ; 0,59; 0,75 ; 0,87
HS= *Hyptis suaveolens*	0,02 ; 0,75 ; 0,91
KS= Khaya senegalensis	0,04 ; 0,44 ; 0,82 ; 0,91

Table N°4: Chromatogrammes of methanol extracts diluted in MeOH in samples in Petrol Ether: Ethyl Acetate (1: 1) (Figures N°5).

Samples	R_f of main stains
CP = *Carapa procera*	0,06 ; 0,17 ; 0,47 ; 0,81 ; 0,91 ; 0,96
CN = *Chamaechrista nigricans*	0,06 ; 0,18 ; 0,32 ; 0,40 ; 0,46 ; 0,56 ; 0,62 ; 0,67 ; 0,83 ; 0,94
EP= *Euphorbia paganorum*	0,05 ; 0,19 ; 0,56 ; 0,70 ; 0,80 ; 0,90 ; 0,95
HS= *Hyptis suaveolens*	0,07 ; 0,90; 0,96
KS= Khaya senegalensis	0,05 ; 0,21 ; 0,47 ; 0,94

Table N°5: Chromatogrammes of methanol extracts diluted in MeOH of samples in Ether Petrol : Ethyl Acetate (2: 1) (Figures N°5).

Samples	R_f of main stains

CP = *Carapa procera*	0,05 ; 0,18 ; 0,56 ; 0,80 ; 0,87 ; 0,96
CN = *Chamaechrista nigricans*	0,06 ; 0,15 ; 0,18 ; 0,34 ; 0,56 ; 0,87 ; 0,94
EP= *Euphorbia paganorum*	0,06 ; 0,17; 0,37; 0,87 ; 0,96
HS= *Hyptis suaveolens*	0,06 ; 0,56 ; 0,87 ; 0,92
KS= Khaya senegalensis	0,07 ; 0,29 ; 0,84 ; 0,94

Figure N°1

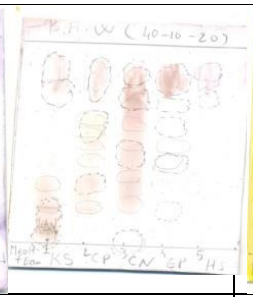

Figure N°2

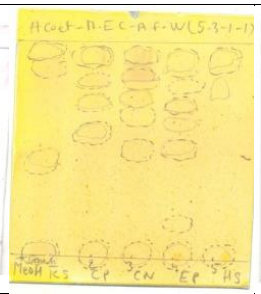

Figure N°3

Figure N°4

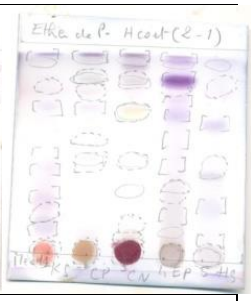

Figure N°5

Chromatogrammes of main chemical compounds principaux constituants chimiques

2. Antiradicals chemical constituents

The main antiradical chemical constituents anti-DPPH are reported in the chromatograms of the extracts in the various solvent systems BAW = *n*-Butanol : acetic acid : water (60:15: 25) and Ethyl Acetate : MethylEthyleCetone : Formic Acid : Water (50:30 :10: 10) Figures N° 6 and N°7

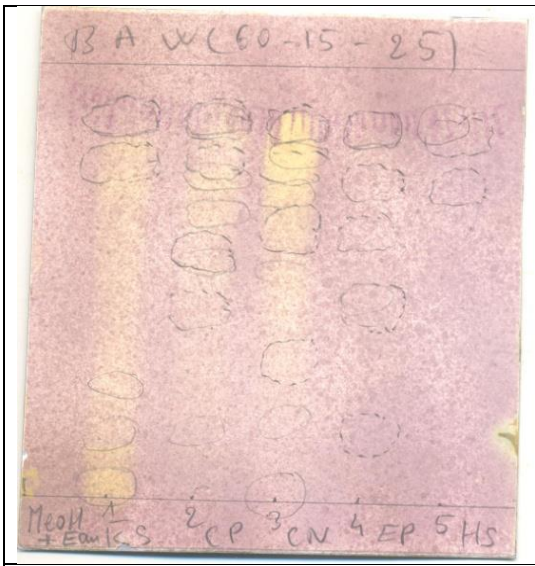

Figure N°6

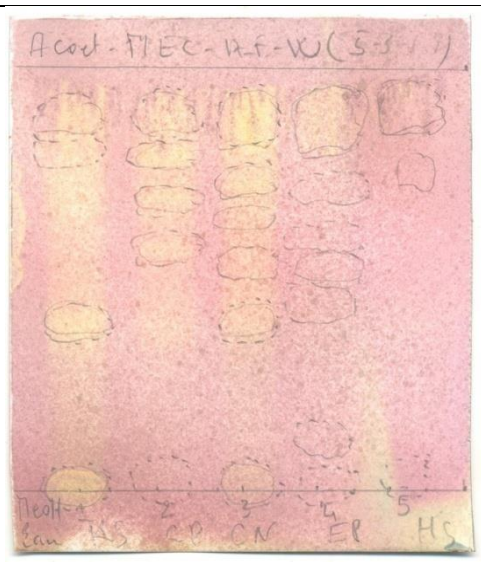

Figure N°7

Annex 5 Efficiency (%) per parts of species, their concentration and their extraction method

Species	Parts	Extraction type	Concentration (mg)	Efficiency (%)	Concentration (mg/ml)
Cassia nigricans	Leaves	EtP	10	0.25	0.416

Cassia nigricans	Leaves	DCM	80	2.00	**2.857**
Cassia nigricans	**Leaves**	**CHCL3**	**110**	**2.70**	**3.666**
Cassia nigricans	Leaves	AcOEt	70	1.75	2.333
Cassia nigricans	**Leaves**	**EtOH95**	**370**	**9.25**	**12.758**
Carapa procera	Leaves	EtP	40	1.00	2.000
Carapa procera	Leaves	DCM	80	2.00	**2.758**
Carapa procera	**Leaves**	**CHCL3**	**160**	**4.00**	**5.925**
Carapa procera	Leaves	AcOEt	60	1.50	1.937
Carapa procera	**Leaves**	**EtOH95**	**130**	**3.25**	**5.200**
Euphorbia paganorum	Leafy branches	EtP	20	0.50	1.052
Euphorbia paganorum	Leafy branches	DCM	90	2.25	**3.750**
Euphorbia paganorum	**Leafy branches**	**CHCL3**	**150**	**3.75**	**7.895**
Euphorbia paganorum	**Leafy branches**	**AcOEt**	**110**	**2.75**	**3.666**
Euphorbia paganorum	**Leafy branches**	**EtOH95**	**120**	**3.00**	**5.000**
Hyptis suaveolens	Leaves	EtP	30	0.75	1.500
Hyptis suaveolens	Leaves	DCM	60	1.50	2.500
Hyptis suaveolens	**Leaves**	**CHCL3**	**80**	**2.00**	**2.963**
Hyptis suaveolens	**Leaves**	**AcOEt**	**70**	**1.75**	2.187
Hyptis suaveolens	Leaves	EtOH95	50	1.25	2.000
Khaya senegalensis	Trunk bark	EtP	10	0.25	0.555
Khaya senegalensis	Trunk bark	DCM	20	0.50	0.800
Khaya senegalensis	Trunk bark	CHCL3	40	1.00	1.378
Khaya senegalensis	Trunk bark	AcOEt	40	1.00	1.428
Khaya senegalensis	**Trunk bark**	**EtOH95**	**90**	**2.25**	**3.913**

Annex 6 Efficacy tests

Table N°1 : : Result of acute toxicity of extemporaneous solution of HS

Extemporaneous solution of HS						
Lot I	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	M	27.78	NONE	NONE	28.1	No acute toxicity at the dose tested
D	M	33.72	NONE	NONE	34.51	
Q	M	32.67	NONE	NONE	32.95	

Table N°2: Result of acute toxicity of extemporaneous solution of CP

Extemporaneous solution of CP						
Lot II	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	M	34.59	NONE	NONE	34.17	No acute toxicity at the dose tested
D	M	30.02	NONE	NONE	29.81	
Q	M	29.46	NONE	NONE	29.61	

Table N°3: Result of acute toxicity of extemporaneous solution of KS

Extemporaneous solution of KS						
Lot III	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion

T	F	28.26	NONE	NONE	28.99	No acute toxicity at the dose tested
D	F	26.57	NONE	NONE	26.60	
Q	F	23.43	NONE	NONE	24.14	

Table N°4: Result of acute toxicity of extemporaneous solution of EP

Extemporaneous solution of EP						
Lot IV	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	F	32.32	NONE	NONE	32.72	No acute toxicity at the dose tested
D	F	33.77	NONE	NONE	34.5	
Q	F	31.63	NONE	NONE	31.62	

Table N°5: Result of acute toxicity of extemporaneous solution of CN

Extemporaneous solution of CN						
Lot V	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	F	28.93	NONE	NONE	29.06	No acute toxicity at the dose tested
D	F	29.65	NONE	NONE	30.16	
Q	F	29.63	NONE	NONE	29.47	

Table N°6: Result of acute toxicity of extemporaneous solution of BAE oil

Extemporaneous solution of BAE oil						
Lot VI	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	F	29.24	NONE	NONE	31.38	No acute toxicity at the dose tested
D	F	30.70	NONE	NONE	32.58	
Q	F	29.02	NONE	NONE	30.40	

Table N°7: Result of acute toxicity of extemporaneous solution of CP oil

Extemporaneous solution of CP oil						
Lot VII	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	F	28.22	NONE	NONE	27.60	1/3rd of mortality in 24h: test to repeat
D	F	26.57	NONE	Morte après 24h	-	
Q	F	25.86	NONE	NONE	25.24	

Table N°8: Result of acute toxicity of extemporaneous solution of distilled water

Distilled water						
Lot VIII	Sex	Weight (g)	Observations after 4h	Observations after 14 days	Weight (g) after 14 days	Conclusion
T	M	30.52	NONE	NONE	30.57	No acute toxicity at the dose tested
D	M	29.20	NONE	NONE	30.18	
Q	M	29.34	NONE	NONE	30.55	

Annex 7 Extract of AETFAT programme - Nairobi May 2017

14:00 - 14.20	8	Stévart T., *et al.*	A fast-track approach for assessing regional species conservation threats: a case study in tropical Africa
14:20 - 14:40	9	Kolawolé S. V., *et al.*	Predicting the potential impact of climate change on the declining agroforestry species *Borassus aethiopum* Mart. in Benin: a mixture of geostatistical and SDM approach
14:40 - 15:00	10	Koko K. I. E. D. *et al*	*Lantana camara* (Verbenaceae): a potential threat to the effectiveness of protected areas to conserve flora and fauna in Benin
15:00 - 15.20	11	Mokake S. E., Chuyong G.B. & Egbe, E.A.	Impacts of selective logging on plant community structure, floristic richness and diversity in the eastern forest of Cameroon
15:20 - 15.40	12	Koros H. K., *et al.*	Population status and and conservation hotspots of *Prunus africana* (Hook F.) Kalkman in South Nandi Forest, Western Kenya
15:40 - 16.00	13	Joseph. F.N.R. & Ravaomanalina BH	Dynamique de la croissance en épaisseur de *Prunus africana* dans la forêt classée d'Ambohilero, Madagascar.
16.00-16.30		Tea &poster viewing	
16:30- 16:50	14	Rivière S. *et al.*	Pesticide plants for organic cotton in Mali
16.50-17.10	15	Wanga, V.O., Schmitt, C. J. & Muhoo,B.	Natural regeneration and species diversity within the Arabuko Sokoke forest and its adjacent agricultural Lands

Thursday, 18th May 2017

SUBTHEME 04: AFRICAN MYCOLOGY & LICHENOLOGY

Leaders: Prof. Thorsten Lumbsch & Dr. George Mugambi

ROOM 3

TIME	NO	PRESENTER	TITLE
10:30 - 10:50	1	Divakar, P.K. et al.	Phylogeny and biogeography of parmelioid lichens
10:50 - 11:10	2	Jefwa, M. J. *et al.*	Challenges in morphological identification of Arbuscular Mycorrhizal Fungi (AMF) in Africa: A hinderance to utilisation
11:10 - 11:30	3	Flavien E.E. P *et al.*	Correlation of some post-harvest growth parameters in vitro of immature pileus of Termitomyces schimperi (pat.) R. Heim (Basidiomycota, Lyophyllaceae) and its mycological interest
11:30 - 11:50	4	Ndong H.C. E & Mounguengui S.W.	Contribution to the knowledge of medicinal mushrooms used in northern Gabon: identification and local importance
11:50 - 12:10	5	Kasongo Wa B. *et al.*	Can we use edible fungi as an incentive for the conservation of EcM dominated forests?

Annex 8 training of women in Ziekorodougou on oil extraction techniques of *Carapa procera* in January 2017

1. Nut crushing

2. Knife to extract pulp

3. Extraction of paste

4. Paste-drying

5. Cooking

6. Oil extraction

Annex 9 Identification and recognition of cotton pests in July 2016

1. Field survey

2. Helicoverpa in jars

Annex 10 *Carapa procera* nuts fermentation (6 months underground storage)

Annex 11 Plantations replenished in August 2016

Annex 12 quantity of plants used to replenish demonstration plantations in August 2016

Used species	Bougouni	Bla	Total/species
Adansonia digitata	870	150	1,020
Khaya senegalensis	900	360	1,260
Parkia bigloboza		255	255
Tamarindus indica	500	360	860
Ziziphus mauritiana		50	50
Carapa procera	700	360	1,060
Faidherbia albida	400	0	400
Total	**3,370**	**1,535**	**4,905**

Annex 13 Title side of presentation at restitution workshop held in Bougouni and Title and Summary pages of 2 students' theses.

Atelier de Restitution des résultats de la campagne 2015-2016

Projet :

Plantes pesticides pour le coton biologique, le bien-être et la biodiversité au Mali

(Bougouni le 28 juillet 2016)

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE SCIENTIFIQUE
INSTITUT POLYTECHNIQUE RURAL DE FORMATION ET DE RECHERCHE APPLIQUÉE (IPR/IFRA) DE KATIBOUGOU

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Sensibilité des graines à la dessiccation et influence du type de substrat et du mode de production sur la croissance des plants de *Lannea microcarpa* Engl. & K. Krause (Anacardiaceae)

Mémoire de Fin de Cycle

Présenté par Ismaïla KEITA pour l'obtention du Diplôme d'Ingénieur des Eaux et Forêts de l'IPR/IFRA de Katibougou

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Thème

ETUDE DE LA PHYSIOLOGIE DE GERMINATION DES GRAINES DE *XIMENIA AMERICANA* L. (OLACACEAE)

RAPPORT DE FIN DE CYCLE

Présenté par
Ali SANOGO pour l'obtention du Diplôme de la Licence en Sciences Agronomiques de l'IPR/IFRA de Katibougou

Mention: EAUX et FORÊTS
Spécialité : Aménagement et Gestion des Ressources Forestières

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Date de soutenance
Octobre 2016

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Annex 14 Quantity of plants produced per nursery

Species	Dramane Coulibaly	Mamby Coulibaly	PRF-Sikasso
Adansonia digitata	800	800	3,450
Khaya senegalensis	700	530	4,500
Tamarindus indica	750	950	3,700
Carapa procera	900	950	6,000
Parkia biglobosa	600	750	2,600
Ziziphus mauritiana	600	900	2,900
Faidherbia albida	650	450	950
Total/nursery	**5,000**	**5,330**	**24,100**

Annex 15 Literature review of 25 pesticidal plant species

Species	**Banked at MSB**	**Germination at MSB**	**Seed Germination references**	**Storage behaviour**	**% of germination**	**% of viability**
Allium cepa	Y	Y	Y (in SBD)	Orthodox	85	85
Allium sativum	N	N	Y	Orthodox	-	-
Azadirachta indica	Y	Y (FAIL)	Y	Orthodox?	61	61
Balanites aegyptiaca	Y	Y	Y	Orthodox	80	80
Bobgunnia madagascariensis	Y	Y	Y	Orthodox	100	100
Capsicum annuum	Y (2 accessions)	Y	Y	Orthodox	90	90
					86	86
Carapa procera	N	N	Y	Recalcitra	-	-

				nt		
Carica papaya	N	N	Y	Recalcitrant	-	-
Chamaecrista nigricans	Y (5 accessions)	Y	Y	Orthodox	100	100
					100	100
					92	92
					no data	no data
					no data	no data
Cassia sieberiana	Y (6 accessions)	Y	Y	Orthodox	86	86
					100	100
					90	90
					35	35
					no data	no data
					no data	no data
Cochlospermum planchonii	Y	Y (FAIL)	Y	Orthodox	15	38
Erythrophleum suaveloens	Y (5 accessions)	Y	Y	Orthodox	80	100
					73	73
					30	30
					10	10
					no data	no data
Euphorbia paganorum	N	N	N	Orthodox	-	-
Hyptis spicigera	N	N	N	Orthodox	-	-
Hyptis suaveloens	N	N	Y	Orthodox	-	-
Jatropha curcas	Y (7 accessions)	Y	Y	Orthodox	100	100
					95	98
					88	90
					100	100
					no data	no data
					no data	no data
					no data	no data
Khaya senegalensis	Y (2 accessions)	Y	Y	Orthodox	100	100
					86	86
Lannea microcarpa	Y	Y (FAIL)	Y	Orthodox?	0	0
Nicotiana tabacum	N	N	N	Orthodox	-	-
Opilia celtidifolia	N	N	N	Orthodox?	-	-
Pentadesma butyracea	N	N	Y (book and website)	Recalcitrant?	-	-
Physalis angulata	Y (6 accessions)	Y	Y	Orthodox	98	100
					96	96
					100	100
					85	85
					100	100
					100	100
Securidaca	Y	Y	Y	Orthodox	80	80

longepedunculata						
Strychnos spinosa	Y (4 accessions)	Y	Y	Orthodox	53	58
					89	100
					no data	no data
					no data	no data
Zanthoxylum zanthoxyloides	Y	Y (FAIL)	Y (book)	Orthodox	0	0

Annex 16 biophysical assessment of the demonstration plantations carried out in November 2016 (height, collar diameter, plant survival rate).

Annex 17 Participant list of the workshop in Tamale, Ghana

Participants' origin	**Number**
IER	**3** (1 coordinator, 1 Manager, 1 laboratory technician)
FENABE	**3** (1 Manager, 2 supervisors)
Cooperative organic cotton producers	**5**
Agriculture Bougouni	**1**
Forestry-environment Bougouni	**1**
Chamber of Agriculture Bougouni	**1**
CMDT Bougouni	**1**
HELVETAS- Bougouni	**1**
Council Cercle Bougouni	**1**

Agriculture National Directorate	**1**
Forestry National Directorate	**1**
Benin OBEPAB	**3**
Kew	**3**
Total	**25**

Annex 18 Pesticide plants and organs used for the treatment of cotton

Key: Ro (root) ; **Ba** (bark) ; **Le** (leaf) ; **Fr** (fruit) ; **Se** (seed) ; **Tu** (tuber)
XXXX: Frequently used ; XXX: Moderately used ; XX: Rarely used
X: Occasionally used; (…) : Names in Bambara

N°	Species	Organs and their frequency of use					
		Root	Bark	Leaf	Fruit	Se	Tu
1	*Allium cepa* (*Djaba*)						x
2	*Allium sativum* (*Laï*)						x
3	*Azadirachta indica (Nimu)*		xxxx	xxxx		xxxx	
4	*Balanites aegyptiaca* (Zègènè)					x	
5	*Bobgunnia madagascariensis* (*Samagkara*)	x					
6	*Capsicum annuum (Foroto)*				xxxx	x	
7	*Carapa procera* (*Kobi*)				xx	xxx	
8	*Carica papaya* (*Maandié*)			x			
9	*Chamaecrista nigricans (Djalaniba)*			xxxx	xx	x	
10	*Cassia sieberiana* (*Sindjan*)	x					
11	*Cochlospermum planchonii* (*Dribala*)			x			
12	*Erythrophleum suaveolens* (*Tali*)					x	
13	*Euphorbia paganorum* (*Baga*)			x			
14	*Hyptis spicigera* (*Bènèfing-djon*)			x			
15	*Hyptis suaveolens (Choukolan*)		x				
16	*Jatropha curcas* (*Bagani*)					xxx	
17	*Khaya senegalensis (Djala)*		xxxx	x			
18	*Lannea microcarpa* (*N'pekuba*)					x	
19	*Nicotiana tabacum (Sara)*			xxxx			
20	*Opilia celtidifolia* (*Korongoe*)			xx			
21	*Pentadesma butyracea* (*Walema*)					xx	
22	*Physalis angulata (Pôpô)*			xxx	xxx		
23	*Securidaca longepedunculata* (*Djoro*)	xxx	x				
24	*Strychnos spinosa* (*Kulekule*)	x					
25	*Zanthoxylum zanthoxyloides* (*Wô*)			xx		x	

Annex 19 Information about cooperatives and collaborating associations of PPP / Darwin (2015 report)

N°	Area/ province	Number of members	Cooperative	Village	Operator	Association type	Planted area (ha)	Starting year	Number of species used
1	Yanfolila	57 (400 M/ 171 W)	Samaguéla	Samaguela	Ousmane Damango	Coopérative bio	0.5	2014	2
2			Samaguéla	Samaguela	Yaya Sagara	Coopérative bio	1	2014	3

3			Samaguéla	Samaguela	Oumar Timbiné	Coopérative bio	1	2014	3
4			Nièmè	Nièmè	Ahmadou Diallo	Coopérative bio	0.5	2015	3
5			Nièmè	Nièmè	Abou Diallo	Coopérative bio	0.5	2015	3
6			Gouna	Gouna	Bréhima Diakité	Coopérative bio	1	2015	4
7			Kandjimamouroula	Kandjimamouroula	Youssouf Diakité	Coopérative bio	0.5	2015	2
8			Kandjimamouroula	Farabacoura	Broulaye Diakité	Coopérative bio	0.5	2015	2
9	Bougouni	428 (300 M/ 128 W)	Madina	Magnabala	Mamourou Samaké	Coopérative bio	0.5	2014	4
10			Madina	Niagnéguéla	Seydou Samaké	Coopérative bio	0.5	2014	4
11			Madina	Faradjélébougou	Abou Diarra	Coopérative bio	0.5	2014	2
12	Kolondiéba	652	Bougoula	Bougoula	Drissa Traoré	Coopérative bio	0.5	2015	4
13			Bougoula	Bougoula	Siaka Konaté	Coopérative bio	0.5	2015	4
14	Bla	865 (598 M /267 W)	Niamana	Niamana	Issa Sountoura	Coopérative bio	0.5	2014	4
15			Niala	Niala	Solo Dembélé	Coopérative bio	0.5	2015	6
16			Niala	Niala	Dramane Coulibaly	Coopérative bio	0.25	2015	6
17			Niala	Niala	Mamy Coulibaly	Coopérative bio	0.25	2015	6
18			Niala	Kozambougou	Kassim Coulibaly	Coopérative bio	1	2015	6
19			Niala	NTorocoro	Dramane Camara	Coopérative bio	0.50	2015	6

Fenced nurseries

20	Bla	-	Niala	Kègnèsso	Moussa Coulibaly	Pépiniériste	0.25	2015	7
21		-	Niala	Niala	Mamy Coulibaly	Pépiniériste	0.25	2015	7
22		-	Niala	Niala	Dramane Coulibaly	Pépiniériste	0.25	2015	5

Annex 20 Seed cotton output of 2016 production: efficacy test of new bio-pesticide formulations compared to the old one

Zone	Name of exploitation	Yield seed cotton Kg/ha		
		Old Formulation	New Formulation	Difference
Kolondiéba	Solomani N°1 Koné	687.5	937.5	250
	Oussoumani Koné	562.5	750	187.5
	Guedjouma Koné	843.75	937.5	93.75
	Solomani Koné	812.5	1062.5	250
	Chaka Koné	*	*	
Yanfolila	Oumar Timbiné	662.5	700	37.5

	Awa Timbiné	575	750	175
	Fousseni Fongoro	518.75	593.75	75
	Mariam Fongoro	450	687.5	237.5
	Alima Fongoro	406.25	562.5	156.25

* Note: Chaka Koné's data were rejected due to non-compliance with organic production standards

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