BIOLOGICAL CONTROL OF *PHYTOPHTHORA MEGAKARYA* IN NIGERIA.

Activity no. PM1-1

Project: Research and technology transfer
Component: Integrated pest and disease management
Executing Partners: Agbeniyi Remi, Sunday, CRIN, Ibadan, Nigeria

Objective: Integrated pest and disease management

Background/Justification:
STCP baseline surveys revealed a relatively high level of expenditures on fungicides in Nigeria to control blackpod disease. Most farmers use either Ridomil Plus (copper oxide plus metalaxyl) or Bordeaux mixture to control *P. megakarya.* The severity of the disease in Nigeria is particularly pronounced in the cocoa growing regions of Cross River State where precipitation is higher. Financial constraints and limited availability of rural credit prevent farmers from achieving the desired control and a low cost environmentally friendly alternative would be a welcome addition to the currently limited IPM arsenal against this disease. In 2002, CRIN pathologists participated in a two week workshop on biocontrol of *P. megakarya* in Cameroon that was hosted by IRAD with the support of the USDA, Mars Inc, and the STCP. At this workshop one of the hypotheses examined was that the origins of *P. megakarya* could be the Korup National Park on the border of Cameroon and Nigeria.

Location/Target Group:
Liquidity constrained cocoa small holders with serious *P. megakarya* disease pressures (Cameroon and Nigeria, parts of Ghana and RCI)

Methodology/Implementation Strategy:

1. Collect microorganisms found in the cocoa ecology of Nigeria. Collections will be undertaken in Oyo, Ondo, and Cross River States of Nigeria.
2. Isolate and screen for their ability to control *P. megakarya* in pathology lab at CRIN. The leaf disc biocontrol screening biotest and the cacao pod husk pieces biotest that have been developed by IRAD and USDA ARS are used for screening biocontrol candidates.
3. Identify promising and effective biocontrol agents that would be employed in small-scale field tests.

Expected Results/Deliverables:
A preliminary set of biocontrol candidates in Nigeria based on laboratory evaluations of their control of *P. megakarya* as document in the technical reporting of this activity.

Milestones:
Laboratory testing of microbial collections established by September 2003
Completed assessment of year one isolates by August 2004.

Key Findings to date:
This is the first year of biocontrol activities in Nigeria.

BIOLOGICAL CONTROL OF *PHYTOPHTHORA MEGAKARYA* THE CAUSATIVE AGENT OF CACAO BLACK POD DISEASE IN CAMEROON.

Activity no.s PM1-2 to PM1-6

Project:	Research and technology transfer
Component:	Research
Executing Partners:	Tondje, Pierre, Plant Pathology Lab/ Biocontrol of Plant DiseasesUnit, IRAD, P.O.Box 2067 Yaounde Cameroon

Objective: Integrated pest and disease management

Background/Justification:
Blackpod disease of cocoa is caused by two species of *Phytophthora.* The more virulent of the two *P. megakarya* can completely devastate smallholder production and income if left untreated. This species is dominant in Cameroon and Nigeria.

Promising results are arising from recent work on isolation and screening of potential biocontrol agents in a collaborative effort between IRAD, USDA, and IITA scientists within the USAID-Chocolate industry sponsored Sustainable Tree Crops Program (STCP). Field samples from pods, leaves and soil were collected from cacao farms and used to isolate microbial populations. •More than 1000 fungal and 274 bacterial endophytes, epiphytes and saprophytes have been isolated and screened. Special interest is now being focused on *Trichoderma* spp. (more than 100 isolates from the natural forest reserve of Dja), *Geniculosporium* spp. (wood decay fungi), *Bacillus* spp *(*spore producing bacteria), and on Actinomycetes .
Several isolates of *Trichoderma species*, were found to be very effective against *P. megakarya,* the black pod disease pathogen. Some microbial strains, exhibiting high antagonistic activity in lab tests are now being field-tested. The preliminary results suggest that biocontrol agents can effectively reduce disease levels in the farm. More effort is needed to understand mechanisms of action of the promising biocontrol candidates, and increase the efficacy of the microbial formulation method developed by IRAD, to insure that farmers will be able to make practical use of them.

Location/Target Group:
Liquidity constrained cocoa small holders with serious *P. megakarya* disease pressures (Cameroon and Nigeria, parts of Ghana and RCI)

Methodology/Implementation Strategy:

Five activities are currently being implemented supported by the STCP and USDA.

PM1-2 *Isolation and screening of antagonistic fungi, bacteria and yeast from cocoa agroforests for biocontrol potentials against Phytophthora megakarya.*

From Center South West and South cacao growing zones of Cameroon, biocontrol candidates are being isolated quantified and stored. The leaf disc biocontrol screening biotest and the cacao pod husk pieces biotest that have been developed by IRAD and USDA ARS are used for screening biocontrol candidates. Biocontrol agents are expected from*: Pseudomonads, Actinomycetes, Bacillus spp*, yeast, *Trichoderma, Gliocladium spp* in different cocoa agroforests of Cameroon.

PM1-3 *Compatibility of promising biocontrol candidates with commonly used chemical fungicides in Cameroon.*

This study will establish the compatibility of promising biocontrol candidates with commonly used fungicides in cacao farming in Cameroon. The objective is to determine threshold use of

these chemicals in IPM strategies including biocontrol agents.

PM1-4 *In-vessel and on-farm small scale composting of cacao pod husks using cellulolytic and mycoparasitism potentials of Trichoderma asperellum* ,

This trial aims to assess the potential of promising *T. asperellum* strains isolated by IRAD to reduce *P.megakarya* primary inoculum on infected cacao pod husks, and to accelerate degradation during composting.

PM1-5-*Development of appropriate fermentation and formulation methods.*.

Some preliminary experiments have already started in 2002 and are expected to be pursued and improved using local agricultural waste materials and some promising Biocontrol strains already available

PM1-6- *Field trials*. *Yearly starting date: early February.*

Field trials for the promising biocontrol strains from Cameroon cacao agrosystems, that has proven to be effective in lab experiments represent the last step of screening for effective biocontrol candidates

Two experimental zones from the main cacao growing zones of Cameroon will be considered:

- Center Province (Nkenlikok) - Nyong et Kelle Division
- South Province (Ebolowa)-Mvila Division

Expected Results/Deliverables:

- Preliminary indications of the on-farm efficacy of four isolates of *Trichoderma aspergillum* in the mycoparisitism of *P. megakarya.*
- Improved formulations of mycopesticides using *Trichoderma aspergillum.*
- Feasibility of using *T. aspergillum* on decomposing cocoa pod husks in farmers' fields to reduce inoculum of *P. megakarya*

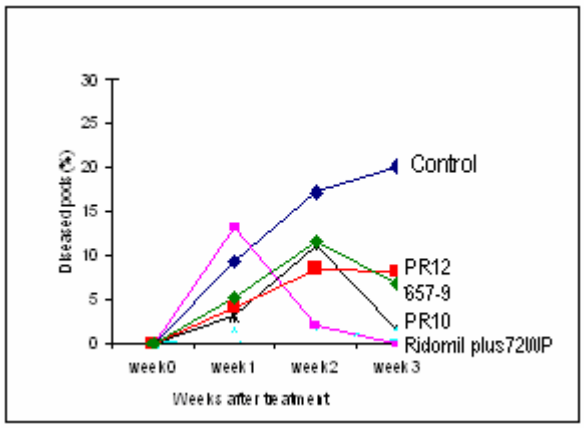
Milestones:

On-farm trials established in two locations by June 2003

Key Findings to date:

- The presence of mycoparasites of *P.megakarya* within 735 endophytic fungi isolated from cacao (*Theobroma cacao*) leaves were screened using the pre-colonized plate method. Nine of isolates (BC177,BC108, BC252, BC134, BC150, BC181, BC118, BC13, BCX) expressed mycoparasitism against *P.megakarya* of which only [BC177], a *Genicolosporium species* isolate expressed some degree of necrotrophic mycoparasitism; the rest exhibited biotrophic mycoparasitism. However eight (BC108, BC252, BC134, BC150, BC181, BC118, BC13, BCX) was observed with. Necrotrophic mycoparasitism has much potential for biocontrol of black pod disease and can be used as any commercial fungicide, but could also be exploited as natural regulators of the disease by reducing the level of primary inoculum of the pathogen in the farm.
- A complex of three very promising biocontrol candidates for *Phytophthora megakarya* the causative agent of cacao black pod disease, (PR10,PR11, PR12) was isolated from a rotten tuber of *Xanthosoma sagitifolium* in a farmers' mixed crop field near Yaounde. A similar level of effectiveness was observed for a microbial agent isolated from the forest reserve of Dja by Dr.Gary Samuels USDA-ARS. These isolates from different origins were identified as isolates of *Trichoderma asperellum*. In the lab, these isolates of *Trichoderma asperellum* has proven to be a very powerful mycoparasite of *P.megakarya.* These strains were also tested by Dr. Prakash Hebbar Masterfoods Inc USA against witches' broom, *Crinipellis perniciosa,* and reportedly expressed mycoparasitism for in lab conditions
- Following demonstrated control in the laboratory, a small preliminary field trial was conducted in 2002 during the month of October in southern Cameroon comparing three isolates, the systemic fungicide Ridomil Plus and a no treatment control. After the removal of all diseased pods and cherelles, a count of healthy non infected pods and cherelles per tree was made. The isolates and

fungicides were applied in week 0 and week 2. At weekly intervals the infected pods per tree were counted and removed; the number of infected pods and cherelles are expressed as a percentage of the healthy pods and cherelles at week 0 (see Figure). The cumulative losses over the three weeks of observation were: control—48%, PR12—21%, Ridomil—16%, PR10—16%; and 657-9—21%.



TRAINING IN THE BIOLOGICAL CONTROL OF *PHYTOPHTHORA MEGAKARYA*.

Activity no. PM1-7

Project:	Research and technology transfer
Component:	Research
Executing Partners:	Akrofi, Alex, CRIG Pathology, Tondje, Pierre, Plant Pathology Lab/ Biocontrol of Plant DiseasesUnit, IRAD, P.O.Box 2067 Yaounde Cameroon

Objective: Integrated pest and disease management

Background/Justification:
Blackpod disease of cocoa is the most damaging disease of cocoa worldwide. It is caused by several species of Phytophthora the most virulent of which is *P. megakarya* which has its probable center of origin in the moist rainforests of Cameroon. This disease agent has been confirmed in Ghana and is posing a potentially serious threat to the cocoa industry in Ghana. Since four years, the *Institut de Recherche Agricole pour le Developpement (IRAD)* in Cameroon has been working on developing biocontrol agents against this disease using techniques developed at the Biocontrol Lab of USDA Beltsville. Their expertise in isolating, screening, and testing biocontrol agents in both the lab and field were the object of a two week training workshop conducted for the benefit of a CRIG pathologist.

Target group: Cocoa pathology researchers in Ghana.

Methodology: In the field and in the laboratory practical training on various techniques.

Expected results: Enhanced capacity for biocontrol research against blackpod in West Africa.

Milestones: Training report by CRIG scientist

The use of molecular markers to assess genetic diversity present in germplasm collections in four West African countries. (USDA Collaborative Activity)

Activity no. GP1-1

Project:	Research and technology transfer
Component:	Research
Executing Partners:	Kolesnikova-Allen, Maria, IITA Ibadan, CRIG plant breeders, CRIN plant breeders, CNRA plant breeders, IRAD plant breeders, CFC participatory germplasm collection and testing project, STCP technology transfer.

Objective: Germplasm improvement and the production and widespread dissemination of quality planting materials

Background:
An adequate supply of cocoa beans of consistent quality through the use of improved planting materials by farmers is a fundamental aspect of sustainable cocoa production. About 70 % of world's cocoa output (2.94 million metric tones) is grown in West Africa with Côte d'Ivoire, Ghana, Cameroon and Nigeria being major producers. Cacao, *Theobroma cacao* L., germplasm, first introduced into West Africa in the 18th century by the Portuguese and Spaniards, consists of genotypes from diverse populations including Amelonado, Upper Amazon Forastero, Trinitario, Criollo and hybrids among these populations. TA wide range of genetic diversity is present both in field gene banks on research stations and in farmer's fields, however, the extent of which information is scarcely available. The use of molecular markers provides the most efficient means of assessing genetic diversity present in germplasm collections.

Location: Major cocoa producing regions of Cameroon, Nigeria, Cote d'Ivoire and Ghana for germplasm collection.

Methodology:

1. Establishment of research network in Nigeria, Cameroon, RCI, and Ghana.
2. Use of a common strategy for germplasm to generate unified database.
3. Sampling of field gene bank collections (Upper Amazon parental clones, F1 and F2 clones) and farmers' collections (sample best and worst performing trees in terms of bean size, productivity, disease resistance etc.)
4. Germplasm collections to remain with NARS, leaf tissue of DNA samples to IITA for molecular analysis
5. Develop capacity of NARS in advanced breeding and molecular biology technologies
6. Linkages with advanced research institutes (USDA, CIRAD, CABI)

Expected results:
1. Comparison of diversity in farmers' fields with the relatively restricted basis of germplasm in breeding programs
2. Comparison of the level of heterozygosity of these materials to assess the possible level of inbreeding
3. Collection of interesting genetic diversity (such as high yielding trees, trees with suspected black pod resistance,) for evaluation in observation plots at research stations and in the planned on-farm trials in the CFC project.

Milestones:

- MOUs signed with Ghana, Nigeria, and Cameroon
- 344 germplasm accessions collected from two gene pools (research and onfarm) in Nigeria

- Ongoing collection in Cameroon, Nigeria and Ghana
- Visits to CABI, CIRAD, USDA
- Joint planning meeting with CFC project on 'Cocoa Productivity and Quality Improvement, a Participatory Approach' and STCP in April 2003
- Two MSc, and 1 PhD student in training

More details on this research are to be found in the Annual Report 2002/2003 for this project. It is available upon request from the STCP secretariat. Contact STCP-WCA@cgiar.org

Ex ante economic evaluation of the costs of alternative methods of delivering improved planting materials to farmers

Activity no. GP1-2 and IA2-1

Project:	Research and technology transfer
Component:	Research and Impact
Executing Partners:	Gockowski, J., and David, S., STCP, Pilot project managers in Ghana, Cameroon, Nigeria, RCI.
Objective:	Germplasm improvement and the production and widespread dissemination of quality planting materials

Background:
One of the findings of the baseline surveys was that in general farmers lack access to improved planting materials. A majority of farmers (67% to 90% depending on country) reported using seedling material from their existing tree stocks as their chief source of planting material. Although improved materials exist with research, it appears that market failures associated with the dissemination of these materials are a constraint on West African competitivity vis a vis other producing regions. As part of the strategy to address this issue, an economic evaluation of the various alternative approaches for bringing these materials to farmers is needed.

Location: Four cocoa producing sites and one cashew producing site of STCP

Methodology:
- Site visits to existing dissemination centers of cocoa planting materials to collect information on technologies and costs.
- Calculation of economic costs and returns of seedgardens, tissue culture, budwood gardens & grafting, hand pollination, cooperative nurseries vs. individual nurseries, bareroot seedlings versus polybag, etc using net present discounted value and economic and social prices.

Expected results:
Recommendations for low cost effective dissemination of improved planting material

Milestones:
- Research protocol and workplan by Sept. 2003
- Site visits to Ghana, Nigeria, Cameroon, RCI completed by January 2004
- Country trip reports
- Technical report by March 2004
- Journal article by June 2004

Key findings to date:

The establishment of multi-strata cacao agroforests in *Chromolaena odorata* and *Imperata cylindrica* fallow

Activity no. RE1-1

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L., Hauser, S. and J. Gockowski. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Objective: Rehabilitation of existing tree crop farms and establishment of new farms on already deforested lands**.**

Background/Justification:
As agricultural productivity for staple food crops increases and as the rural exodus from the forest zone proceeds, short fallow land dominated by *Chromolaena odorata* and grasses is increasingly available for conversion to agronomically more sustainable land use systems such as mixed tree crop systems. In addition to the revenue potential of these land use systems, they may also conserve important biodiversity, maintain watershed and landscape functions and may help in stabilizing local climatic patterns by supporting hydrological cycles. However, short fallow dominated by *C. odorata* and grasses is likely to present serious fertility and weed competition constraints during the establishment phase due to previous nutrient depletion and a built up of the weed seed bank caused by repeated cycles of annual cropping. In addition there may not be any shade available in such land use systems to protect the young cacao during the establishment phase.

Farmers in the IITA research village of Nkometou III have expressed a strong interest to re-establish such systems and a researcher designed on-farm trial was implemented.

Location/Target Group:
Asset- poor smallholders in areas of degraded forest with extensive degraded Chromolaena and Imperata fallows.

Methodology/Implementation Strategy:
The experiment had a two– factorial design, conducted in nine replicates. Plot size is 17.5 m x 17.5 m. Factor 1, shade treatment with four levels: plantain; cooking banana; *Inga edulis* Mart. and alleys of natural regrowth dominated by *Chromolaena odorata* were established / created in September/October 1999. Factor 2 is fertilizer regime. Four fertilizer regimes were imposed: nil; N only; P, K, Ca, and Mg; and P, K, Ca, and Mg with N. Fertilizer was applied in one dose in October 2000 to the cacao plants.

The research objectives are to:

1. Determine with farmers options for establishing cacao agroforests in degraded short fallow bush land
2. Assess the ability of two *Musa* spp. varieties to provide shade to the young cacao and generate income through production of plantain and banana bunches during the first 3 to 4 years after planting the cacao.
3. Determine the effect of fertilizer on growth of cacao, fruit trees, timber trees and the yield of the *Musa* spp.
4. Evaluate the economic costs and returns of establishing multistrata cacao agroforests in *Chromolaena odorata* and *Imperata cylindrica* fallow.
5. Determine the dynamics of carbon sequestration in such cacao agroforest

All plots were planted to upper strata trees, replacing 9 of either the Musa spp. or *Inga edulis* plants.

Five fruit trees: three *Persea americana* and two *Dacryodes edulis*, two timber trees *Terminalia ivorensis*), and two timber / fruit trees, *Ricinodendron heudelotii* were planted on a three by three pattern in each plot. Planting dates were September / October 1999 for *D. edulis* and *P. americana*, June 2000 for R. *heudelotii*, and July 2001 for *T. ivorensis*. Seedlings from selected trees of a local cacao variety were planted in May 2000 at 1600 ha^{-1}.

It is also intended to continue with the tree crop component measurements in all fields as before.

Expected Results/Deliverables:

1. Agronomic evaluation report of establishment trial
2. Economic evaluation report of establishment trial including cost of carbon sequestration over four years.
3. Recommendations for establishing multiproduct cocoa based agroforests on degraded land.
4. Three conference presentations
5. Two book chapters
6. One draft articles for publication in peer reviewed journals.

Milestones:

- Tree crop component measurements made in May 2003, November 2003, March 2004, May 2004, November 2004.

Key Findings to date

- After two years the estimated costs per ha to establish the trial ranged from 376,000 to 1,299,000 FCFA/ha (See Tables 1-3) depending on treatment.
- Fire hazards in the dry season are a major constraint to the establishment of agroforests particularly on Imperata lands
- Initially, cooking bananas had more leaves, larger and higher pseudostems and more suckers than the plantains, thus provided more shade, yet may have caused more competition. *Inga edulis* trees had reached up to 4 m height.
- Survival of cacao of the first dry season until January 2001 was 73.4% and neither affected by the shade regime nor by the fertilizer regime. Survival was higher in blocks with good growth of shade plants.
- Growth of timber and fruit trees was assessed twice per year. After measurements on all components in May/June 2002, fields were weeded in October and all system components were re-measured (height, girth, leaf numbers etc). In all years, shade treatment had no impact upon survival. By October 2002, growth was generally best in the plantain temporary shade treatment and fertilizer regime had no significant effects. Plantain is susceptible to root nematode pests and leaf diseases therefore it is prone to uprooting and maintains fewer leaves than cooking banana. This treatment produced the least shade and, given that local plantain (AAB) has a poor performance relative to (ABB) cv. Fougamou cooking bananas, competition would be lower in these plots.

- By October 2002, survival of *Terminalia ivorensis* was 71 % across treatments and trees averaged 245 cm height. Stem diameter and branching were significantly higher in the plantain treatments and growth was worst in the bush. However, number of non-lignified juvenile green branches was highest in the bush treatment, suggesting a developmental delay. By October 2002, growth of *Ricinodendron heudelotii* was generally unaffected by shade treatment although stem diameter was higher in plantain plots than in others.
- By June 2003, survival of safoutiers was significantly lower in the bush treatments than in the other shade treatments with highest survival in the inga (66%) and plantain (54%). Remaining trees were significantly taller (276 cm), with a higher mean diameter (50 mm), higher canopy cover and branching level in the plantain shade treatment than in the other treatments. By June

2003, survival of *Terminalia ivorensis* was affected by treatment with highest survival in the cooking banana (74%), plantain (71%) and inga (69%), all significantly higher than in the bush plots (47%). Remaining trees had a significantly higher diameter (61 mm) in plantain plots than in the other treatments. Fertilizer had an effect on branch formation with greatest formation in the 'all fertilizer' and exchangeable cations and P treatments, with least in the unfertilized control. There were few treatment effects on the growth of *Ricinodendron heudelotii* although stem diameter was higher in plantain plots than in others.

- The two indigenous fruit trees and *Terminalia ivorensis* are robust enough to establish on short fallow land. Early growth was best in the least shaded plantain treatment. The system might be adjusted so that the trees are planted concurrently with the temporary shade crop.
- Fertilizer had few impacts on survival or early growth so is not recommended

Table 1. Partial establishment costs for year 1 and 2 of four temporary shade treatments, no fertilizer application (F cfa per ha).

	Shade treatments			
	Inga edulis	Cooking banana	Plantain	Bush control
Labor costs	208,770	204,440	206,857	152,348
Variable costs	251,207	278,189	278,189	171,980
Fixed costs	51,906	51,906	51,906	51,906
Total costs	511,883	534,535	536,953	376,234

$1 USD= 740 F cfa

Table 2. Additional costs of fertilizer treatments (F cfa per ha)

	Fertilizer treatments			
	No fertilizer	Nitrogen	Cations	Cations plus Nitrogen
Labor costs	0	1,586	5,340	5,868
Variable costs	0	11,700	746,824	758,524
Fixed costs	0	0	0	0
Total costs	0	13,286	752,163	764,392

$1 USD= 740 F cfa

Table 3. Total costs of establishment for year 1 and 2, all treatment combinations (F cfa per ha).

	No fertilizer	Nitrogen	Cations	Cations plus Nitrogen
Inga	511,883	525,169	1,264,046	1,276,275
Cooking banana	534,535	547,821	1,286,698	1,298,927
Plantain	536,953	550,239	1,289,116	1,301,345
Bush	376,234	389,520	1,128,397	1,140,626

$1 USD= 740 F cfa

Effects of shading, soil water content, fertilizer, soil type on germination and growth of local cacao

Activity RE1-2

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L., and Hauser, S. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Objective: Rehabilitation of existing tree crop farms and establishment of new farms on already deforested lands**.**

Background/Justification:
In recent trials in Cameroon, we have found no relationship between shade level and cacao growth. Therefore a microcosm experiment has been started to assess the effects of various shade levels and the interaction with soil water content, fertilizer and soil type on cacao germination and early growth under controlled conditions. This is being conducted at IITA Mbalmayo using soils from forest and chromolaena systems adjacent to the sites of the agroforest trial established in 1999.

Location/Target Group:
On-station trial in Mbalmayo. Results will be used to make recommendations to farmers on the establishment of cacao

Methodology
The experiment is a four-factorial design in five replicates. Shade levels are 0 and 67% imposed with shade cloth. Soil water contents are 50 and 25% saturation. The soils were initially analysed for N, P and exchangeable cations and it was found that the chromolaena soil was lower in total N (0.60 mg g^{-1}), exch. Ca (0.08 mg g^{-1}) and exch. Mg (0.045 mg g^{-1}) than the forest soil with 1.60 mg g^{-1} total N, 0.48 exch. Ca and 0.171 mg g^{-1} exch. Mg. The fertilizer treatment was the addition of urea, calcium and magnesium carbonate fertilizers to the chromolaena soil so the total amount of nutrients in the microcosm was equal with that in the forest soil microcosm. This permits to separate effects of nutrients and other factors different between chromolaena and forest soils. Microcosms are covered by moveable clear plastic tents during rain showers and during the night but left open at all other times.

Variables, measured weekly, are establishment success, leaf and flush leaf number, height and jorquette formation. At termination, dry matter and nutrient content of plants will be assessed, permitting a full nutrient budget to be calculated. Soil evaporation rates are measured and plant transpiration estimated. Soil temperature measurements are made in a weekly basis.

Given the low available P status of both forest (0.0031 mg g^{-1}Mehlich P) and chromolaena 0.0028 mg g^{-1} Mehlich P) soils, a companion experiment has been established comparing different levels of TSP fertilizer application in full light conditions. Variables measured are identical to those described above.

Expected Results/Deliverables:
- Technical report on the impacts of shade, soil water, fertilizer and soil type and their interactions on cocoa establishment and early growth.
- Draft article for publication in peer reviewed journals.

Milestones
Trial initiated in May 2003

Trial to be completed in December 2003 and repeated in 2004, ending in December 2004
Results to be communicated to local farmers groups near Mbalmayo

Key findings to date: **n/a New**

Establishment of cocoa in timber plantations thinned to various densities

Activity RE1-3

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L., and Hauser, S. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Project Output: Rehabilitation of existing tree crop farms and establishment of new farms on already deforested lands**.**

Background
Past research efforts (see above) of establishing cocoa on degraded land have been hampered by drought conditions. Neither shade nor fertilizer had consistent significant effects on cocoa survival and early growth. The most likely factor, water availability, during the dry season cannot be managed under the given circumstances, as irrigation is not economically feasible.

It appears that other niches for cocoa need to be identified and tested. One such system can be timber plantations with timber rotation times similar to the productive lifetime of cocoa. However, the success of such systems may depend on the density of the timber trees, affecting both soil water regimes and shading.

Rehabilitating logged over forest by converting to timber plantations is a common practice in Cameroon and the most common species used is *Terminalia ivorensis*. *Terminalia ivorensis* produces a straight bole and a small crown and therefore can be felled with low damage to the understorey crop.

Location / Target groups
On farm. Farmers with forest resources wiling to establish smallholder agroforests with Terminalia and cocoa.

Methodology
It is proposed to plant cocoa as an understorey in a 14-yr old *Terminalia ivorensis* plantation. These plantations have tree densities, imposed in 1995, of 0, 40 and 192 stems per hectare. It is proposed to clear the understorey of the plantation and plant cocoa and monitor the effects of different tree densities and intercropping with food crops on cocoa survival and growth, and if the experiment is extended, on production.

Expected results/deliverables:
By December 2003, peer reviewed journal article in press on the development of such systems
By January 2005, technical report on the agronomic feasibility of establishing *Terminalia* – cocoa agroforests in logged over secondary forest.
By January 2005, draft article for peer reviewed journal

Milestones:
By July 2003 establishment of cocoa seedling nursery (2000 trees).
By August 2003, all timber trees measured.
By August 2003, discussions completed with collaborating farmers
By September 2003, full biophysical assessment of site and initial land preparation
By December 2003, full assessment of aboveground carbon stocks in different treatments
By December 2003 peer reviewed journal article in press on the development of such systems
By April 2004, planting of cocoa

Measurement of cocoa establishment and growth, shade canopy development from April 2004 on a monthly basis, as well as soil water content

Key findings to date:
n.a. NEW

Effects of fungicide application upon yield and sustainability indicators (third year trial)

Activity ER1-1

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L. and Hauser, S. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Objective: Enhancing environmental services provided by tree crop based cropping systems

Background/Justification:
Fungicide to control blackpod *(Phytophthora megakarya* Bras. & Griff) is the main external input used in cacao (*Theobroma cacao* L.) systems in southern Cameroon. However, at fluctuating cocoa prices, the spraying regime recommended by the manufacturer is not always profitable. Therefore the effects of a reduced spraying regime need to be assessed.

Since 1994 farmers have been subject to extremely variable farmgate prices, ranging from less than USD$0.50/kg to $1.60/kg. When prices are low, many cocoa farmers either reduce resource allocations to cocoa or even abandon production altogether and devote their efforts to other enterprises. In a survey by Norgrove conducted in eight southern Cameroonian villages, on average farmers classified 33 % of their cacao holdings as abandoned. Given increased interest in cacao production due to higher market prices, it is important to know what yields can be attained in previously abandoned fields and what is the yield response to fungicide.

This research is examining the recuperative capacity of a 35 yr old cocoa agroforest in southern Cameroon that had been abandoned for three years during a period of low prices prior to the implementation of the trial in 2001.

Location/Target Group:
Farmers' abandoned cocoa farms near Zoatoupsie, southern Cameroon (3^{o} 51'N and 11^{o} 27'E)
Diversified smallholder producers with mature shaded cocoa agroforests in southern Cameroon

Methodology/Implementation Strategy:
The experimental design is an on-farm randomised complete block design in three replications with three treatments: (1) 'high concentration' Ridomil® plus 72 WP (active ingredients 600g kg^{-1} Cu_2O and 120 g kg^{-1} metalaxyl (methyl N-(2,6-di-methylphenyl)-N-(methoxyacethyl)-DL-alaninate, $C_{15}H_{21}NO_4$) at the manufacturer's recommended application rate; (2) 'low' concentration' at one third of the recommended rate (3) zero- no spray. Also, a secondary forest control (unsprayed) was used as a comparison for each block. The experiment was replicated three times. Plot size was 25 m x 25 m.

The research objectives are to assess the effects of high and low fungicide applications versus a zero-spray control on *P. megakarya* incidence, cacao flowering, cherelle production and yield, environmental parameters and nutrient cycling in cacao fields previously abandoned for three or more years. Environmental parameters include litterfall, soil faunal activity, termite species richness, understorey plant diversity, decomposition rates. Additionally a full inventory of overstorey tree species, as well as carbon stocks of the cocoa farm will be calculated.

Expected Results/Deliverables in 2003/2004:
Technical report on third year of trial
Draft article for peer reviewed journal

Presentation of research results with collaborating farmers and the cocoa associations of the surrounding villages

Milestones:
By March 2003 Litter and soil sampling completed
By April 2003 Assessment of understorey plant diversity and biomass followed by weeding
By May 2003 Assessment of flowering and cherelle production of cocoa
June – December 2003 cocoa harvests, with estimates of cocoa yield and nutrient exports including production per tree
Bi-weekly assessment of soil faunal activity during rainy season
Fortnightly assessments of yield losses to *P. megakarya* and physiological wilt
By April 2004 data analysis and reporting

Key Findings to date
Spraying recommendation. In the first year of rehabilitation, returns to capital were higher in the high application rate treatment whereas in the second year, returns were higher in the low application rate treatment. Yields of cocoa were 358, 203 and 48 kg dry beans ha^{-1} in the high, low and zero spray treatments, respectively in the first year of rehabilitation yet generally much lower due to lower pod set early in the second year, probably due to rainfall differences and this was a general feature in the area. In 2003, harvests up until early September 2003 are 266, 95 and 8 kg dry beans ha^{-1} high, low and zero spray treatments, respectively and thus are projected to exceed previous years in the sprayed treatments once the main crop data are added. The profitability of the spraying depends on the yield level and thus farmers are recommended to spray at the recommended rate in years when pod set is high and at the low rate in years with poor pod set.

Blackpod and yield losses. There are no differences between treatments in flowering and cherelle production at the beginning of the season, thus there are no differences in yield potential. Conservative estimates of losses to blackpod to date this calendar year, based on mass of diseased pods of mature size only, converted to dry bean mass, were 189 kg ha^{-1} in control plots, 71 kg ha^{-1} in low and 37 kg ha^{-1} in high. Evidently, without spraying, yield losses to blackpod disease approach 100%, even with weekly phytosanitary harvests and complete removal of infected material from the cocoa field. This confirms data from previous years. Therefore phytosanitary harvest is not recommended because it cannot prevent complete yield loss. Consequently 'organic' cocoa is not an option in shaded cocoa fields. In addition, removal of diseased pods is a significant nutrient export which may have negative long-term consequences on sustainability.

Ecology. In the first and second years, there was no effect of fungicide treatment on soil faunal activity. Cu concentrations of earthworm casts were lower than Cu concentrations in soil for the cacao plots. This suggests that, unless the Cu is being compartmentalized at the sub-cellular level inside earthworms, that earthworms are avoiding copper uptake. Earthworms could avoid copper uptake by feeding at deeper soil layers. Casts derived from the high fungicide application plots had a higher clay proportion than those derived from the low fungicide application and zero-spray treatments. This suggests that the earthworms may be feeding more in the deeper soil layers where the clay content was higher to avoid the soil with higher Cu concentrations near the surface.

Cocoa quality. Fungicide treatments have no significant effects upon cocoa bean size, although individual bean mass was significantly greater at the late season harvests. Copper concentrations in cocoa beans were extremely low (13-17ppm) and were not different between treatments.

Comparison of shaded and unshaded cocoa systems

Activity ER1-2

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L., and Hauser, S. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Project Output Enhancing environmental services provided by tree crop based cropping systems

Background
This work is being conducted in west-central Cameroon where unshaded cocoa is far more common than in the south.

Location/Target Group: Small holder cocoa agroforests in southwest Cameroon near Nyombe

Methodology/Implementation Strategy:

Establishment of experiment using paired shaded and unshaded sites, of similar age and management history are being selected for ecological and economic characterisation to assess shade effects.

In each plantation, 10 m x 10 m plots will be delineated.

Within each of these plots, the following are sampled/measured/counted:
1. Cocoa tree density and growth characteristics
2. Non-cacao tree species density and girth. Tree mass of hardwoods calculated using tropical hardwood equations.
3. Pod counts, yield estimates and nutrient exports by cocoa
4. Soil sampling (5 augers per plot, bulked) 6 depths (up to 552 samples) for exch. cations, N, P, organic carbon, pH, Al, texture, bulk density, once per year. Soil water content (0-20 cm only) using TDR, weekly.
5. Pests and diseases
   scoring of *Phytophthora* spp. on pods (in July, the season of highest incidence)
   scoring of lichen and bryophyte density on trees
   scoring of capsid damage to trees
6. Litter sampling, litterfall monitoring and decomposition. Fine litter and dead wood collected from 1.25 x 1.25 m area in centre of plot. Litterfall traps (2 per plot) to be installed and collected once per week for a calendar year. Litter decomposition: the litter sampled initially can be incubated at specific times (two) to get an idea of the decomposition rate of fresh litter versus the litter already in place. It is assumed that there will be pronounced litter fall phases after which such litter should be incubated.
7. Soil faunal activity. Semi-quantitative assessment of termites, divided into functional groups. Monitoring of earthworm casting activity (once per week) and quantitative sampling of earthworms at conclusion of experiment. Identification or grouping by functional group - epigeic species should be specifically included.

Expected results

Draft review article for international journal on shade effects
Technical report on the impact of shade on the agronomic performance of cocoa agroforests.

Recommendations to farmers in the area on shade management

Milestones:
By June 2003. Visit and select potential sites for study.
By November 2003 Observation plots established
By December 2004 Completion of measurements
By January 2005, draft article

Key findings to date:
n.a. NEW

Farmers' agronomic and ecological knowledge and management of cocoa multistrata systems in southern Cameroon.

Activity no. ER1-3

Project:	Research and technology transfer
Component:	Research
Executing Partners:	N. Bidzanga, IRAD, F. Sinclair, University of Wales Bangor, UK., J.Gockowski & S.Weise, STCP
Objective:	Enhanced environmental services provided by tree crop based cropping systems

BACKGROUND/JUSTIFICATION.
The aim of this research is to acquire local knowledge about the agronomy and ecology of multistrata cocoa systems in Southern Cameroon, and then use this in combination with scientific knowledge, to improve and diversify systems productivity and provide ecosystem services. Understanding current knowledge and practice of farmers is vital to improving livelihoods of cocoa smallholders and sustainability in cocoa production (Sinclair, 2002). Farmers in Southern Cameroon have a long tradition of maintaining tree biodiversity in their cocoa farms, which is complementary to what we know scientifically. The diversity and complexity of those systems are also the basis for important ecological functions that drive and maintain the productivity of the systems. Acquiring this knowledge is a sensible first step in improving complex, multistrata cocoa systems in Southern Cameroon.

Developing knowledge based systems that incorporate local knowledge and scientific knowledge (walker et al., 1995; Sinclair and Walker, 1998; 1999) underpins research and development in a number of ways that are set out below and discuss by Sinclair and Walker (1999).

1) *Productivity and livelihoods*.
Common understanding of local knowledge is a prerequisite for building effective partnerships with local producers. Increasing smallholder productivity requires interventions appropriate to their circumstances, building upon rather than changing what people already know and do (Thapa et al., 1995)

2) *Ecosystem services*.
Some farmers have used biodiversity for longer than agricultural and forest scientists have had an interest(Sinclair and Joshi, 1999), therefore, their knowledge is a potent resource.

Study area.
The farmers' agronomic and ecological knowledge and management of cocoa multistrata systems in Southern Cameroon were surveyed in 4 different locations distinguished by agrocological zone, land use intensity, population density and market access. These were:
- Akok, distinguished by low population density and poor market access in evergreen rain forest with low land use intensity.
- Awae (medium population density and some market access)
- Nkongmesse (high population density and good market access) in strongly degraded semi-deciduous forest with moderate to high land use intensity, and
- Ndikinimeki, distinguished by high population density and reasonable market access in the forest savannah transition zone with high land use intensity.

Methodology.
The approaches used for collection of farmer knowledge are drawn from the techniques of

Participatory Rural Appraisal (PRA). The research involved the following steps:

- Participatory community and group level work were held with the existing Non Governmental Organisations (NGOs), Common Initiative Groups (CIGs), traditional leaders of the targeted locations and staffs of the Ministry of Agriculture.
- Semi-structured interviews guided by participant observations were conducted with a purposive sample of 15 knowledgeable cocoa growers per location drawn from strata where differences in knowledge are presupposed: i.e., age and gender. Interviews were complemented with field visits. Farmers' statements of knowledge were recorded with a tape recorder.
- A further sample of 60 informants per location were identified for the testing of validity of abstractions.
- Formal representation of knowledge in a computer-readable form that facilitates storage and flexible access of the knowledge.
- Comparative analysis of farmers' knowledge within and across study locations.
- Analysis of the implication of farmers' knowledge for research.

Key findings.

Four knowledge bases from the study locations, completed with a knowledge base from scientists, documenting local and scientists agroecological knowledge of cocoa multistrata systems have been compiled. An initial investigation of distribution of local knowledge within and amongst the site has been conducted. Widespread shared local knowledge of the functional attributes of 65 upper and mid-canopy tree species, together with their implications for farmers' decision making have been documented. This was integrated with local knowledge about soil types, site selection and cocoa disease and pest occurrence and control.

The amount of knowledge was found to vary both across locations and was influenced by ecology and socio-economic inducements factors, and within locations according to age groups and gender. On the bases of the number of statements abstracted from farmers' knowledge and practices (745 in total), 100% of the amount of knowledge was held by men and 29% by women, whilst 99% were held by older men and 67% by younger men. The knowledge among the three groups of farmers is not exclusive. Detailed results have been presented at international fora in Indonesia and Ghana.

Expected outputs.

Acquiring local agronomic and ecological knowledge is an efficient method of using available knowledge to formulate and target research, while facilitating effective communication amongst stakeholders. Immediate outputs are:

- documentation of local knowledge to reduce the risks of erosion of the amount of knowledge both across locations and within locations over times.
- Identification of gaps in knowledge and definition of research priorities based on analysis of these.
- Ultimate outputs are improvements in living standards of cocoa farmers and sustainability of cocoa production through well targeted research and extension.

2003/2004 Milestones

1). Completion of field work in Cameroon and supervisory visit in Cameroon by Dr Fergus Sinclair, University of Wales, Bangor, UK, Co-ordinator of the activity. Anticipated timing 22 September 2003.

2). Review and consolidation of knowledge acquisition phase and detailed planning of remaining research. Anticipated timing 22 September 2003.

3). Completion of writing up of research as a thesis for educational purposes. Sept. 2004.

Literature review of effects of shade on cacao and cocoa systems

Activity ER1-4

Project: Research and technology transfer
Component: Research

Executing Partners: Norgrove, L., and Hauser, S. IITA-HFC Cameroon, BP 2008 Yaounde Cameroon, l.norgrove@cgiar.org

Project Output Enhancing environmental services provided by tree crop based cropping systems

Background

A recent review of shade management in cacao (Rice and Greenberg 2000) included the role of shade in pest and disease control, however, there was no reference to the impact of shade on *Phytophthora* diseases. Brown leaf spot of coffee *Cercospora coffeicola* is reduced in shaded coffee plantations, compared with unshaded ones (Nataraj and Subramanian 1975, quoted in Beer et al. 1998). However, in contrast, damage from tea blister blight, *Exobasidium vaxans* (Exobasidiaceae, Homobasidiomycetidae) was more severe under shade (Visser et al. 1961). It is thus important to summarise the available literature to assess the impact of shade on various fungal diseases of tree crops.

Furthermore, recent research here has not been able to establish the relationship between shade, growth and yield. It is thus required to conduct a review of the literature, particularly investigating and assessing the validity of the grey literature and older publications from the 18 and 19 th centuries. This work complements experimental work on shade effects.

Methodology/Implementation Strategy:
Collection and evaluation of existing literature on the effects of shade on cocoa growth

Expected results

Draft review article for international journal on shade effects
Technical report on the impact of shade on the agronomic performance of cocoa agroforests.

Milestones:
By July 2003, literature collection completed.
By October 2003, literature collection documented and databased in Endnote
By April 2004, draft article

An evaluation of genetic and geospatial factors associated with red powder of Cameroon bulk cocoa origins

Activity no. PH1-1

Project:	Research and technology transfer
Component:	Research
Executing Partners:	Nyasse, S. IRAD, Kolesnikova-Allen, Maria, IITA Ibadan,, J.Gockowski, STCP
Objective:	Improving post harvest practices to ensure quality and improved livelihoods

Background:
Prior to the dissolution of the national marketing board, bulk cocoa with Cameroon origins in most years received a premium for the reddish color of cocoa powder from pressed Cameroon beans. Since liberalization with the backwards integration of multinational bulk processors into Cameroon origins this premium has disappeared. What once was approximately a $5 million annual quality premium for Cameroon cocoa has now become a discount of between $5-10 million relative to other West African origins. The first step in recapturing the quality premium for Cameroon origins is to better understand the origins of this reddish color. The country-wide IITA/USDA germplasm collection exercise about to begin in Cameroon provides an opportunity for piggy backing this activity and will hopefully provide information on the genetic origins as well as spatially explicit environmental factors. Geographical coordinates will be associated with the germplasm collection allowing for spatial mapping of reddish color. Both the genetic and spatial information will be useful for reestablishing the quality premium through the trade and information systems currently being developed in the STCP.

Location: Major cocoa producing sites in Cameroon (East, South, Central, and Southwest Provinces)

Methodology:
This activity will be included as part of the field gene bank and farmers' germplasm collection in Cameroon which will gather material (leaf tissue and pods) from 500 trees. An adequate quantity of cocoa pods will be gathered to enable testing for the reddish color of cocoa powder. Each accession will be geographically inputted using GPS.

Expected results:
- Understanding of the genetic versus environmental origins of the reddish color of Cameroon cocoa powder
- Spatial representation of red color.
- Trade strategy for marketing cooperatives to recapture price premiums once received for red color.

Milestones:
- Accessions collected and cocoa beans sent for color analysis by December 2003
- Technical report by June 2004

Analysis of major production and marketing constraints at the household level in current cocoa and cashew systems of West Africa

Activity no. PR1-1

Project: Research, technology transfer and impact
Component: Research
Executing Partners: Nkamleu, B., Gockowski, J. (STCP), Jonas Mva-Mva (Odeco - Cameroon); Charles Akinola (EFDI - Nigeria), Olivia Agbenyega (UST – Kumassi, Ghana), Keho Yaya (ENSEA - Cote d'Ivoire), Moustapha Kane (SPCIA - Guinea).

Objective: Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background/Justification:
Beginning in 1998 a partnership emerged between the chocolate industry, development agencies, and concerned governments, focusing on the issue of sustainable rural development in cocoa-producing areas. In May 2000 in Accra, Ghana, the Sustainable Tree Crops Program (STCP) was launched to implement this partnership's activities. The goal of the STCP is to improve the well-being of smallholder farmers through the development of sustainable tree crop systems that increase productivity, raise smallholders' income, conserve biodiversity, use natural resources sustainably, and offer stable, socially responsible development prospects for farmers and their workers. Among the STCPs first activities was the conduct of baseline surveys in the major cocoa-producing regions of Cameroon, Côte d'Ivoire, Ghana, Nigeria and Guinea
.
This activity consists of writing country reports of this baseline survey.

Location/Target Group: Cocoa growing regions of Cameroon, Nigeria, Ghana, Cote d'Ivoire, and Cashew growing regions of Guinea

Methodology/Implementation Strategy:

1. Conduct baseline surveys of tree crop producing households in Nigeria, Cameroon, Cote d'Ivoire, Ghana, and Guinea (n=1000 to 1350) to gather quantitative data on production systems, tree stock investment behavior, labor utilization, tree stock quality, agronomic practices, farm gate marketing channels, and rural service provision. Spatial coverage of minimum of 80 percent of production area with the exception of Nigeria (45%).
2. Conduct econometric and descriptive analyses.

Expected Results/Deliverables in 2003/2004:
Country specific recommendations for improving the productivity and competitiveness of West African cocoa and cashew production and marketing based on report findings.

Milestones:
Analysis for all countries will be complete by September 2003
Draft reports by November 2003

Key Findings to date
Tabular analysis for Cameroon, Nigeria, Cote d'Ivoire and Guinea completed.
Report writing for Guinea completed.

Analysis of labor and land markets in cocoa sector of West Africa

Activity no. PR1-2

Project: Research, technology transfer and impact
Component: Research
Executing Partners: Gockowski, J. (STCP), Nkamleu, B., (STCP)

Objective: Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background:
Labour and land are the two principal factors of cocoa production in West Africa. The demand for largely unskilled labour in the production of cocoa is met by various sources of labour supply. Policy makers require sound analysis of the principal factors affecting labour demand and supply relations which include technology innovations, trade liberalization, demographic growth, ethnicity, cocoa price shocks, enterprise size, and global media communication on the issue of child labour. The tenure arrangements that connect labour and land for growing cocoa are also important. This work draws upon the recent STCP studies of labor markets from baseline surveys and child labor surveys in Cote d'Ivoire to arrive at a set of policy recommendations.

Location: Cocoa sector of West Africa.

Methodology:
Normative analysis of findings on labor demand & supply and land tenure in cocoa sector of West Africa. Linkage of labor to tenure issues in the cocoa sector of West Africa developed.

Expected results:
Policy recommendations for alleviating pressure on labor and land institutions in West Africa

Milestones:
Completed and revised draft submitted for publication August 2003
Published book chapter by Dec. 2003

Key findings:
- Demand for labor in the cocoa sector of West Africa is estimated to have increased at an annual rate of 4.8 percent since 1980 with largest portion of this increase occurring in Cote d'Ivoire
- Estimated fulltime employment in cocoa is approximately 850,000 person-years, with 50 to 60 percent of labor demand incurred during the three-month main harvest season.
- Exchange rate devaluations, cocoa market liberalization, and developed country protection of their agricultural sectors have all contributed to higher prices of cocoa relative to food crops stimulating production and hence labor demand
- The largest source of labor is drawn from household family members.
- The most common forms of contractual labor involve (1) the engagement of sharecroppers under leasehold tenure arrangements and (2) labor engaged on a task basis.
- Land disputes and civil conflict in Cote d'Ivoire currently threaten the sustainability of recent production gains.
- Abusive child labor practices as reported by the media are relatively rare in incidence and require criminal investigation and interdiction.

Analysis of the role of child labor in West Africa tree crops sector

Activity no. PR1-3

Project:	Research, technology transfer and impact
Component:	Research
Executing Partners:	Gockowski, J. and Nkamleu, B., (STCP), Bazzi-Veil, L. and Jean-Baptiste, E. (CEPRASS Cote d'Ivoire), Jonas Mva-Mva (Odeco - Cameroon); Charles Akinola (EFDI - Nigeria), Olivia Agbenyega (UST – Kumassi, Ghana), Moustapha Kane (SPCIA - Guinea).
Objective:	Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background:
An increased labour demand in the cocoa sector of West Africa has placed pressure on existing labour institutions that in conjunction with historically low world cocoa prices from the late 1980s through the late 1990s may have contributed to abusive child labour practices on the part of some cocoa producers. Beginning in September 2000, media allegations of child labour trafficking and child slavery on cocoa farms in Cote d'Ivoire were made. These reports led to threats of consumer boycott and legal action, which threaten the livelihoods of millions of West African producers. Producer and worker surveys conducted under the auspices of the Sustainable Tree Crops Program and ILO's International Program for the Elimination of Child Labour in 2001 and 2002 examined labour relations. The survey analysis of labor demand and supply relations with a special focus on the role of children is the chief focus of this activity.

Location: Cocoa sectors of Cameroon, Ghana, Nigeria, and Cote d'Ivoire

Methodology:
Descriptive and econometric analyses of survey data focused on the extent and role of child labor in the cocoa sectors of Nigeria, Cameroon, Cote d'Ivoire, and Ghana.

Expected results:
Policy recommendations for addressing the developmental issues surrounding child labor in the cocoa sector of West Africa

Milestones:
- Three STCP baseline survey monographs on labor with special focus on child labor for Nigeria, Cameroon & Ghana currently in press at IITA since July 2003.
- Qualitative study of child labor in the cocoa sector of Cote d'Ivoire by CEPRASS translated into English and currently under editorial review for publication by IITA—STCP.
- Synthesis report on child labor findings for RCI, Nigeria, Cameroon, & Ghana on IITA website.
- Draft report on producer/worker survey of child labor in Cote d'Ivoire translated into English (October 2002).
- Abridged report on producer/worker survey of child labor in Cote d'Ivoire by December 2003.

Spatial analysis of baseline survey

Activity no. PR1-4

Project:	Research, technology transfer and impact
Component:	Research
Executing Partners:	Nkamleu, G., Gockowski, J. (STCP), Eric Wood, (USGS - USA)
Objective:	Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background/Justification:
In May 2000 in Accra, Ghana, the Sustainable Tree Crops Program (STCP) was launched to implement the partnership emerged between the chocolate industry, development agencies, and concerned governments, focusing on the issue of sustainable rural development in tree crops - producing areas. Among the STCPs first activities was the conduct of baseline surveys in the major cocoa-producing regions of Cameroon, Côte d'Ivoire, Ghana, Nigeria and Guinea.

This activity will make use of data collected during this survey to spatially represent production and marketing parameters.

Location/Target Group:
Cocoa sectors of Cameroon, Nigeria, Ghana, Cote d'Ivoire; and cashew sector of Guinea

Methodology/Implementation Strategy:
The method consists of matching administrative divisions in the baseline data base with those available in existing GIS layers and calculating descriptive statistics for selected variables.

Expected Results/Deliverables in 2003/2004:
Spatial differentiation of major production and marketing parameters in the cocoa sector of West Africa for informing spatially explicit policies and rural development efforts.

Milestones:
Cote d'Ivoire spatial representation developed July 2003
Complete descriptive means analysis by September 2003
Draft report by Nov 2003

Investigating the determinant of child labor and schooling in cocoa sector

Activity no. PR1-5

Project: Research, technology transfer and impact
Component: Research

Executing Partners: B. Nkamleu and J. Gockowski (STCP), Anne Kielland (World Bank – Washington), Jean-Baptiste, E. (CEPRASS Cote d'Ivoire).

Objective: Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background/Justification:
There is a growing concern that some agricultural goods in developed country markets are being produced under "exploited" forms of labor practices. In particular, since 2001, there has been persistent report that children are being used in cocoa production in Côte d'Ivoire.
In response to those anecdotal reports of slavery on cocoa plantations in Ivory Coast, International Institute of Tropical Agriculture (IITA) and in close consultation with the Program for the Elimination of Child Labor of the International Labor Organization (ILO/IPEC) undertook investigative surveys of child labor practices on cocoa plantations, to establish the extent of such practices.

The challenge for child labor policy is to remove children away from work and toward schooling. To this end, there is a need to better understand the interplay between work and schooling as well as household decision making behavior with respect to child's time allocation. This activity investigates child labor and child schooling issues in the cocoa sector of Cote d'Ivoire, with the aim to identify determinant factors that can help to design a multi-angle policy approach towards the elimination of child labor.

Location/Target Group: Cocoa farmers of d'Ivoire Cocoa.

Methodology/Implementation Strategy:
To capture information on the status of abusive forms of child labor in Cote d'Ivoire, an extensive national survey was conducted in 2002. The survey was the first effort towards building a knowledge base on cocoa producing household and its workforce.

A total of 1501 households and over 250 villages, hamlets and cocoa "camps" across the cocoa belt of Cote d'Ivoire were visited. More than 11600 persons were enumerated in the survey.

Econometric analysis is being conducted of the determinants of child labor and schooling in the cocoa sector of Cote d'Ivoire.

Expected Results/Deliverables in 2003/2004:
Policy recommendations for increasing children's schooling in rural cocoa producing areas relative to work.

Milestones:
- Analysis completed in Juillet 2003
- Draft article completed in August 2003
- Expected publication date March 2004

Review of regional agricultural labor markets and agricultural labor migrations.

Activity no. PR1-6

Project: Research, technology transfer and impact
Component: Research
Executing Partners: G. B. Nkamleu (STCP)

Objective: Identification and analysis of policies and institutions for the increased competitiveness of the West African tree crops sector

Background/Justification:
This activity consists of a review of the literature on agricultural labor in West and Central Africa. The general objectives of this research are to collate and facilitate access to information on research work covered a wide array of topics related to rural employment and unemployment in West and Central Africa. This review is part of the background work of the child labor component of the Sustainable Tree Crop Program (STCP).

The main objective is to understand labor practices and history in the region and to broaden the understanding beyond child labor issues.

Location/Target Group: Labor institutions of West and Central Africa.

Methodology/Implementation Strategy:
Conducted literature review in various locations on issues connected to agricultural labor and rural migration in West Africa.

Expected Results/Deliverables in 2003/2004:
Compilation of knowledge on labor markets, institutions, and migration in West Africa in order to better inform agricultural labor policies.

Milestones:
Draft report submitted in June 2003
Annotated bibliography

Key Findings

- The impact of colonial inheritance on agricultural labor is highlighted.
- Literature and research on rural migration in West and Central Africa are synthesized.
- An overview of population trend and agricultural labor dynamic in the region is presented.
- The historical roles of policy and institutions on agricultural labor are explored.
- Literature on child labor, gender, impact of diseases on labor productivity particularly HIV and malaria is synthesized.

Groundwork for startup of farmer field schools in Ghana, Nigeria, Cameroon, and Cote d'Ivoire

Activity no. FS1-1

Project:	Research, technology transfer and impact
Component:	Technology transfer
Executing Partners:	J. Gockowski (STCP), B.K. Matlick (Consultant WCF), Braima James (Systemwide Initiative on IPM, IITA Cotonou).
Objective:	Strengthen farmers' decision-making capacity for sustainable production of tree crops through the implementation of FFS

Background:
With the collapse of parastatal efforts in cocoa marketing and cocoa extension, there is currently only a weak if any ongoing extension efforts in most countries (as substantiated by baseline survey results). To address this need STCP is testing several approaches to technology transfer. For complex processes such as disease and insect attacks which are embedded in a complex net of ecological functions, discovery learning with farmers has been shown elsewhere to lead to improvements in productivity and sustainability. The farmer field school approach is a discovery learning method for addressing such issues and has been chosen by the Program for pilot phase testing. It is targeted for all of the four cocoa producing pilot projects. This activity involved the initiation of discussions in the various sites with partners and potential partners.

Location:
Pilot project sites in Cameroon, Nigeria, Ghana, and Cote d'Ivoire

Methodology:
1. Pilot site visits with research, extension, NGOs, and farmer organizations.
2. Recruitment of regional knowledge transfer specialist
3. Pilot project action planning for initiation of FFS
4. Recruitment of master trainers.
5. Planning of sensitization workshop for pilot project managers, master trainers, and resource persons
6. Curriculum development workshop planning for Master trainers and resource persons

Expected results:
Inclusion of FFS approach for discovery learning of principles of IPM and other management issues in pilot project programs

Milestones:
- Recruitment of master trainers by March 2003
- Recruitment of regional knowledge transfer specialist by March 2003
- FFS sensitization workshop by April 2003
- FFS curriculum development workshop by April 2003
- Startup of farmer field schools by June 1, 2003

Coordinating FFS curriculum development (Cabi Bioscience collaborative activity with co-funding from DFID)

Activity no. FS1-2

Project:	Research, technology transfer and impact
Component:	Technology transfer
Executing Partners:	Vos, J. (CABI Bioscience), S. David and J. Gockowski (STCP), resource persons from IRAD, CRIN, CRIG, CNRA, and IRAG
Objective:	Strengthen farmers' decision-making capacity for sustainable production of tree crops through the implementation of FFS

Background/justification:
Experiences from Asia and elsewhere have shown that farmer field schools are an effective way to introduce farmers to knowledge intensive practices such as IPM and ICM. Farmer field schools (FFS) is a discovery based learning approach which seeks to strengthen farmers' knowledge of integrated crop management and improve their decision making capacity. The FFS approach was initiated with Asia with a focus on IPM in annual crops such as rice and vegetables. Innovations in FFS curricula include gender advocacy, public health issues and livestock. There is relatively little experience world wide with conducting FFS on perennial crops, hence the need to adapt the approach, training of trainers and curricula to longer season crops such as cocoa and cashew. For cocoa, work is needed on how to integrate social messaging on child labour into the FFS curriculum.

Location/target group:
STCP pilot projects; other projects in West Africa and worldwide

Methodology
Protocols are developed during curriculum development and TOT workshops attended by STCP teams and resource persons. Protocols are validated by facilitators/master trainers prior to use in FFS.

Activity objectives:
- Develop a curriculum for use in farmer field schools on cocoa and cashew in West and Central Africa
- Integrate social messaging on child labour into FFS curriculum

Expected results/deliverables:
- Validated curriculum for integrated FFS on cocoa and cashew
- STCP cocoa IPM manual
- Protocols on child labour

Milestones:
- Curriculum development workshop for cocoa (March 2003) and cashew (2004)
- Cocoa FFS curriculum tested in pilot field schools (May-December 2003)
- Further cocoa curriculum development during TOT workshops (August-September 2003, 2004)
- Publication of STCP cocoa IPM manual (early 2004)

Status:
- A five day workshop was held in March 2003 to initiate the process of developing a curriculum for FFS on cocoa. The workshop was attended by pilot project managers, master trainers, resource persons from cocoa research institutes in the region and facilitators from IITA, CABI and a cocoa IPM project in Indonesia supported by ACDI-VOCA. Workshop

participants developed 24 discovery learning exercises which will be compiled into an STCP IPM training manual for FFS. Three protocols were developed on the use of child labour in tree crop production. Protocols developed at the workshop were validated during the workshop or during pilot FFS in the four STCP countries.

- Follow-up training of trainers workshops are also being used to develop/validate new protocols. The second round of TOTs (August-September 2003) will introduce new protocols on fermentation, use of the ballot box test and disease zoos.
- In July-August 2003, CABI Participatory IPM Specialist completed a six week consultancy to provide feedback on the FFS curriculum and work on the STCP cocoa IMP manual.

Technical backstopping and monitoring of FFS (Cabi Bioscience and WCF collaborative activity with co-funding from DFID and WCF)

(Sept 5 version)

Activity no. FS1-3

Project:	Research, technology transfer and impact
Component:	Technology transfer
Executing Partners:	S. David (STCP), Vos, J. (CABI Bioscience), BK Matlick (consultant WCF), Brice Gbaguidi (IITA Cotonou), resource persons from IRAD, CRIN, CRIG, CNRA, and IRAG
Objective:	Strengthen farmers' decision-making capacity for sustainable production of tree crops through the implementation of FFS

Background/justification:
Tree crop farmers in West Africa have limited access to new information and technologies. Most rely on radio for technical information. Experiences from Asia and elsewhere have shown that the farmer field school approach is an effective way to introduce farmers to knowledge intensive practices such as integrated pest management (IPM) and integrated crop management (ICM). Farmer field schools (FFS) encourage discovery learning to strengthen farmers' knowledge of integrated crop management and improve their decision making capacity on a broad range of technical issues, including marketing. FFS also provide a platform for empowerment and may incorporate an advocacy agenda on social issues such as gender equality and the use of child labour in agriculture. In line with STCP's goal to take an integrated approach to developing sustainable tree crop production systems, the program seeks to institutionalize the FFS approach within farmer organizations and, to a lesser extent, national extension systems.

Location/target groups:
STCP pilot sites in Cameroon, Nigeria, Ghana, Cote d'Ivoire

Methodology/implementation strategy:
- Field visits by participatory extension specialist and email communication with master trainers and pilot project managers to provide informal training, technical guidance and feedback;
- Field visits by CABI's Participatory IPM specialist to provide informal training, technical guidance and feedback;
- Structured training of master trainers and facilitators.

Activity Objectives:
- Test and adapt the farmer field school methodology to tree crops;
- Assess the feasibility of implementing FFS with tree crops in the West/central African context;
- Develop capacity among farmer organizations and national extensions systems to implement farmer field schools and institutionalize the approach within farmer organizations

Expected results/deliverables:
- Manual on how to implement FFS for tree crops
- M&E framework for FFS
- Well trained facilitators and master trainers

Milestones (for technical backstopping):
- Initial monitoring to provide feedback on quality of FFS (August-October 2003)
- Develop 3 year pilot FFS program (August-October 2003)

- Develop M&E framework for FFS and initiate implementation (end of 2003)
- Training/review workshop for master trainers (November 2003)
- Publication on the process of initiating FFS for tree crops (2004)
- Manual on how to implement FFS for tree crops completed (2005)

Status:

- CABI Participatory IPM Specialist completed a six week consultancy to provide feedback on the quality of FFS in July-August 2003
- Three year pilot program for testing and adapting FFS methodology drafted based on observations from monitoring activities in Cameroon. Three phases are envisaged, with the following activities:

Phase 1 (training and validation). Curriculum development workshop; initial training of trainers for FFS facilitators and master trainers; follow-up TOTs; protocols validated during pilot FFS; facilitators graduate after completing several TOTs; awareness raising among farmer organizations on the FFS approach to encourage buy in and ownership. (2003)

Phase 2 (implementation and monitoring): Implementation of year-long field schools by certified facilitators monitored by master trainers; some FFS supported by farmer organizations (2004)

Phase 3 (Institutionalization): New FFS, some self financed, are initiated by experienced facilitators working in pairs with new farmer facilitators, most or all supported by farmer organizations (2005)

- M&E framework for FFS activities drafted and circulated among STCP team members

Development of a monitoring, evaluation and impact assessment framework for project interventions.

Activity no. IA1-1

Project:	Research, technology transfer and impact
Component:	Impact
Executing Partners:	Pilot project managers and regional coordination (J. Gockowski, S. David, S. Weise)
Objective:	Measure economic, environmental and social impacts of tree crop systems & interventions.

Background:
As the initial phase of the STCP is meant to test new innovations and approaches for trading systems, information and knowledge dissemination, and capacity development of farmer organizations it is important that the program monitor and evaluate interventions with great attention. The ultimate objective is to measure the impact (economic, social, and environmental) of these interventions. As the first step in the process a workshop was held in Ibadan Nigeria to begin to explore ME&I and to discuss the processes for accomplishing the impact objective.

Location:
IITA Ibadan campus

Methodology:
Roundtable discussion of ME&I issues by activity interventions. Facilitation by program leader.

Expected results:
Consensus set of indicators by different outputs for inclusion into monitoring and evaluation frameworks of activity workplans.

Milestones:
Workshop held in July 2003
Workshop report finished Sept 2003

Development of a monitoring, evaluation and impact assessment framework for project interventions.

Activity no. IA1-2

Project: Research, technology transfer and impact
Component: Impact
Executing Partners: Gockowski, J. (STCP/IITA)

Objective: Measure economic, environmental and social impacts of tree crop systems & interventions.

Background:
To assist in the monitoring and evaluation of interventions in the tree crop sector in West Africa, development agents require an assessment framework illustrated with practical examples of the peculiarities of the West African tree crop sector.

Location: Cameroon

Outline of framework:
1. Develop theory of market failures,
2. Economic measurement issues ,
3. Normative prescriptions (e.g. child labor) and
4. Measurements issues specific to perennial tree crops.
5. Participatory monitoring and evaluation
6. Ex ante impact assessment for prioritising potential interventions
7. Ex poste impact assessment for prioritising future interventions and scaling out
8. Use input from IA1-1 report to illustrate approaches to different categories of problems

Expected results:
Methodology for monitoring and evaluating tree crop interventions and measuring their impacts (both potential and actual) developed and disseminated among STCP partners and other stakeholders.

Milestones:
- Draft framework developed Sept 2003
- Finalized framework to be distributed to pilot project managers in Oct 2003
- Continued updating and illustration with practical examples through 2005.

An economic and environmental comparative assessment of the impacts of smallholder tree crop systems versus slash and burn annual cropping in Cameroon, Indonesia and Brazil.

Activity no. IA1-3

Project: Research, technology transfer and impact
Component: Impact
Executing Partners: Gockowski, J. (STCP/IITA), S. Vosti (U. of California, Davis), T. Tomich (ICRAF—ASB, Nairobi)

Objective: Measure economic, environmental and social impacts of tree crop systems & interventions.

Background:
A comparative assessment of tree-based cropping systems versus annual cropping systems in terms of sustainable production and ecosystem integrity in the humid tropics was the object of this study. Included in this effort were an examination of social policy and political mechanisms for increasing the spatial extent of cocoa agroforests in Cameroon. The assessments are founded on a comparison of biophysical and socioeconomic parameters based on plot-level assessments of agro-ecosystem performance combined with an institutional and policy analysis of land use change. The novelty of the study is its ability to draw meaningful cross- site comparisons from Latin America, Africa and Asia based on the application of standard economic and biophysical methodologies developed by ASB in all sites. Six examples of extant multi-strata agroforests cultivated by small holders are considered and compared with annual food crop (Cameroon, and Indonesia) and pasture systems (Brazil).

Location: ASB Benchmark sites in Brazil, Indonesia and Cameroon

Methodology:
1. Comparative analysis of ASB agroecological data for ag landuses from three pantropical rainforest sites
2. Construction of policy analysis matrixes for assessing relative profitability and market failures.
3. Risk analysis of price and production.

Expected results:
- Methodology for assessing tradeoffs faced by smallholders regarding tree crop production developed and
- Policy recommendations for alleviating these tradeoffs.

Milestones:
- Databases on plant biodiversity, below ground biodiversity, carbon stocks, and economic and financial costs and returns for different production systems.
- Journal publication December 2003.

Key findings:
- Equity concerns are an issue for agroforestry systems. At the same time, the creation of tree-based assets by family labor (i.e., the investment of 'sweat' equity) offers a clear pathway for alleviating rural poverty. Assisting asset-poor households escape from poverty traps by this approach warrants detailed consideration by national policy makers and donor agencies alike.
- The productivity measures (the returns to land and labor using the prices received and paid by farmers and the productivity of food value ha^{-1}) revealed that in each site, one of the agroforests was the most productive with the largest difference in the Amazon where the

predominant livestock system gave a negative NPV. However, in Cameroon and Sumatra, extensive agroforests (as opposed to intensive agroforests) were both less productive in monetary terms than the food cropping systems in these sites. This was more pronounced for the measure of land productivity than for the labor measure.

- Regardless of the land use system, opening up forestland to agricultural use entails significant declines in carbon stocks. If forestland is converted to short fallow or continuous annual cropping or livestock systems almost all of the carbon will be lost out of the system and deforestation is complete. If instead it is converted to complex agroforests (e.g. jungle rubber or cocoa agroforests) at least half of the carbon will probably be lost. On the positive side, reforesting abandoned pastures in the Amazon, or *Imperata* wastelands in SE Asia, or *Chromolaena* bush fallows in West Africa with complex agroforests could sequester significant net amounts of carbon ranging from an average of 58.3 tC ha^{-1} in Brazil to 87.2 tC ha^{-1} in Indonesia.
- Biodiversity maintained in complex agroforests plays a key role in the sustainable livelihoods of people living along the forest margins as illustrated by findings from Cameroon. A household survey of non-timber forest products conducted in the Atlantic coastal rainforest among five communities of mainly Bulu ethnicity found that 280 animal species were consumed and more than 500 plant species were utilized for 1 100 different uses(Van Dijk 1998). The species richness (total number of different species ha^{-1}) within cocoa agroforests was 79% of the ecologically diverse primary coastal rainforest forest and exceeded species richness in some secondary forest types. In contrast, the richness of young fallow lands associated with slash and burn cropping was only 48% of the primary forest.
- Policy options for affecting the long-run tree crop supply response include subsidies for new planting and replanting
- Market liberalization, globalization and agricultural policy are on center stage across the developing world and efforts to assist production and marketing systems capitalize on the potential gains from liberalization while minimizing the potential costs are needed.
- Liberalization in general tends to reduce marketing costs as more competition is introduced into the sector. In general, large marketing margins are due either to monopolistic elements in the marketing system that are earning excess profits or to high real marketing costs due to underinvestment by government in road infrastructure.
- One of the biggest problems inhibiting tree-based systems is the general weakness of financial institutions for meeting the credit needs of both producers and market agents.
- Small holder perennial crop systems vary in the intensification of production for numerous reasons. In the ASB Forest Margins Benchmark Area of southern Cameroon, rural population pressures, market institutions, and market access were identified as among the major driving forces of the agricultural intensification process in cocoa plantations.
- Underinvestment in public goods especially road infrastructure and agricultural research & dissemination inhibit production and competitiveness in the tree crops sectors of many developing countries.

Ex ante economic evaluation of the costs of alternative methods of delivering improved planting materials to farmers

Activity no. IA2-1 and GP1-2

Project:	Research and technology transfer
Component:	Research
Executing Partners:	Gockowski, J., and David, S., STCP, Pilot project managers in Ghana, Cameroon, Nigeria, RCI.

Objective: Exante evaluations of potential innovations, institutional change and policy change on net social welfare

Background:
One of the findings of the baseline surveys was that in general farmers lack access to improved planting materials. A majority of farmers (67% to 90% depending on country) reported using seedling material from their existing tree stocks as their chief source of planting material. Although improved materials exist with research, it appears that market failures associated with the dissemination of these materials are a constraint on West African competitivity vis a vis other producing regions. As part of the strategy to address this issue, an economic evaluation of the various alternative approaches for bringing these materials to farmers is needed.

Location: Four cocoa producing sites and one cashew producing site of STCP

Methodology:
- Site visits to existing dissemination centers of cocoa planting materials to collect information on technologies and costs.
- Calculation of economic costs and returns of seedgardens, tissue culture, budwood gardens & grafting, hand pollination, cooperative nurseries vs. individual nurseries, bareroot seedlings versus polybag, etc using net present discounted value and economic and social prices.

Expected results:
Recommendations for low cost effective dissemination of improved planting material

Milestones:
- Research protocol and workplan by Sept. 2003
- Site visits to Ghana, Nigeria, Cameroon, RCI completed by January 2004
- Country trip reports
- Technical report by March 2004
- Journal article by June 2004