CFC/ICCO/Bioversity Project

Cocoa Productivity and Quality Improvement: a Participatory Approach

Final Completion Report

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CFC/ICCO/BIOVERSITY Project on Cocoa Productivity and Quality Improvement, a Participatory Approach

FINAL COMPLETION REPORT

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1. PROJECT SUMMARY

1.1. Project Title	Cocoa Productivity and Quality Improvement, a Participatory Approach[1]
1.2. Project Number	CFC/ICCO/26 (CFC)
1.3. Project Executing Agency (PEA)	Bioversity International (Rome, Montpellier)
1.4. Supervisory Body	ICCO (London)
1.5. Starting/Completion Dates	01/06/04 and 31/05/2010
1.6. Collaborating Institutions	CATIE (Costa Rica), CCI (PNG), CEPLAC (Brazil), CNRA (Côte d'Ivoire), CRIG (Ghana), CRIN (Nigeria), CRU (Trinidad), INIA (Venezuela), INIAP (Ecuador), IRAD (Cameroon), MCB (Malaysia), MALMR (Trinidad), UNAS (Peru) and the University of Reading (UK)
1.7. Co-financing Institutions	CRA (UK), CIRAD (France), Guittard (USA), Mars Inc. (USA/UK), USDA and WCF (USA)

1.8. Project Financing:

Total Costs	US$ 10 504 553
of which:	
CFC Grant	US$ 3 916 120
Co-financing Contributions	US$ 3 338 443
Counterpart Contributions	US$ 3 249 990

[1] Referred to as the "*CFC/ICCO/Bioversity project*" or simply as the "*project*")

2. BACKGROUND AND CONTEXT IN WHICH THE PROJECT WAS CONCEIVED

2.1. Key Commodity Issues

Cocoa beans are the basic feedstock for the chocolate industry and are grown in a belt between 15° North and 15° South of the equator, while the most significant cocoa consumption is in Europe and North America. Cocoa beans are exported from producing countries for processing into cocoa liquor, butter and powder, mainly in consuming countries, although in recent years there has been an increase in the amount of cocoa processing in producing countries.

Total world cocoa consumption or grindings for the 2000/01 season was estimated at 3,041,000 tonnes as world grindings of cocoa beans steadily increased from around 2.6m tonnes in 1995/96 to exceed 3.0m tonnes in 2000/01. The largest cocoa consuming region, estimated to account for up to 40% of world grindings in 2000/01, is West Europe, followed by North America with 27%. As a result of growing markets for chocolate products, worldwide demand for cocoa beans has steadily increased at between 2 and 3% per year over the last two decades. Although 'bulk cocoa' is the major part of the world cocoa production, demand for fine flavour cocoa is steadily increasing. Fine flavour cocoa products depend largely on the genetic make-up of cocoa varieties, *i.e.* traditional varieties such as *Trinitario* and *Nacional* provide special flavours that become more and more compensated for in the market. Consumption of cocoa in chocolate products is strongly correlated with the economic development of a region, hence the high consumption trends in Europe and in North America. These well-developed markets can be regarded as mature, with cocoa and chocolate products facing strong competition from other snack food sectors. The potential for increased cocoa and chocolate consumption is greater in developing markets like Eastern Europe, the Mercosul region, China, and India. Cocoa and chocolate purchases by consumers should closely follow the economic development of these consumer markets with cocoa containing products moving away from their current status as a luxury item, to become more affordable as disposable incomes increase. A significant change in cocoa consumption patterns in the last few years mainly in the developed markets of Europe and N. America, has been the growth of cocoa usage (mainly as powder) in non-confectionery products such as drinks, baked goods and ice cream. Increased uses for cocoa powder, constant innovation and new product development by chocolate manufacturers, stimulating niche markets and the relentless drive by manufacturers into developing markets show that the overall outlook for cocoa consumption is strong.

Total world cocoa production for the 2000/01 season was estimated at 2,842,000 tonnes and production of cocoa beans has fluctuated within a range between 2.6m to 3.1m tonnes between 1997 and 2002. Côte d'Ivoire is the world's largest producer of cocoa beans and produced an estimated 1,175,000 tonnes during the 2000/01 season. Cocoa cultivation spread to Côte d'Ivoire from Ghana, encouraged by a combination of government policy, available land, and migrant labour supply. In West Africa, cocoa is typically produced by farmers on smallholdings with an average farm size between 1 ha to 3 ha. Cocoa production in Africa faces constraints related to climatic change, ageing tree stocks, incidences of pests and diseases, soil fertility, land tenure, economic dependence on one or two principal cash crops and smallholder production systems. In total, West Africa is responsible for 66% of world cocoa production. A number of cocoa-producing countries rely on cocoa exports for a significant proportion of the foreign exchange earnings that they need to finance economic development projects and to service external debt obligations. For example, cocoa exports account for around 70% of total export earnings in São Tomé and Principe; cocoa-derived export earnings represent a substantial proportion of all export earnings in Côte d'Ivoire (35%), Ghana (30%), Cameroon (7%), Equatorial Guinea (4%) and Sierra Leone (3%). Around 10.5 million agricultural workers are employed in cocoa cultivation in Africa. It also contributes to capital flows from developed to developing economies.

In Asia, Indonesia is the largest cocoa producer producing an estimated 408,000 tonnes over the 2000/01 season. The growth of Indonesian cocoa production has been mainly a result of smallholder farmers on the island of Sulawesi. Malaysian cocoa production has decreased due to high production costs, mainly related to cocoa pod borer control. In Papua New Guinea, the main production constraint is probably high incidence of *Phytophthora* pod rot and stem canker. Brazil is the largest producer of cocoa in the Americas, with production of 163,000 tonnes estimated in 2000/01(ICCO). Brazilian production has decreased dramatically in recent years mainly due to the spread of the devastating witches broom disease. Close to 90% of all cocoa produced is grown by smallholder farmers and, for an estimated 2.5mn farmers, cocoa is their main farming activity. The size of cocoa plantings is typically between 2.5 and 5 hectares, with average yields between 300kg/ha to 750 kg/ha. World cocoa prices are inherently volatile due to fluctuations in supplies, induced by climatic change and weather patterns, which can exacerbate the prevalence of pests and diseases.

The world cocoa market is one of the most dynamic and inherently volatile of commodity markets. The 3 to 7 year gestation period between planting and bearing economically significant production leads to an unstable "boom-bust" cyclical pattern. Cocoa production is also highly susceptible to growing conditions (climate) and to the spread of diseases and pests, which can lead to wide variations in yields. One of the main factors undermining sustainability of cocoa production is the susceptibility of cocoa to several devastating diseases and pests: *Phytophthora megakarya* and cocoa mirids in Africa, witches' broom and monilia in the Americas, and vascular-streak dieback (VSD) and pod borer in Asia. These diseases and pests account for significant losses in cocoa crop yield worldwide. This situation is likely to worsen as *P. megakarya* is spreading within Ghana and from there into Côte d'Ivoire, monilia is spreading into the northern part of Central America and into the Amazon basin in South America, whereas the cocoa pod borer is spreading in Indonesia. The low short-term elasticity of demand to cocoa prices combined with the instability of annual cocoa production typically results in wide fluctuations in price levels in both the short and long term. A period of structural supply deficit combined with climate-induced reductions in crops in the 1970's led to critical shortages in supply and a consequent sharp rise in prices to record high levels. This prompted uncontrolled expansion of cocoa cultivation in existing and new areas and subsequently to a rapid increase in production in the following two decades. The recovery in prices seen in 1983/84 and 1984/85 was a direct consequence of an adverse impact of the *El Niño* weather phenomenon on world production, which sharply reduced yields in a number of cocoa-growing countries.

Despite demand outstripping supply at the global level for most of the 1990's, cocoa prices continued to decline, remaining at historical lows for most of the decade. Exceptionally favourable growing conditions in West Africa contributed to record crops in the 1999/2000 cocoa season, depressing cocoa prices to 30-year lows. This failure of world market prices to respond more positively to changes in the global supply-demand balance during the past decade is attributed to a number of factors.

- Firstly, the existence of a relatively large volume of cocoa-bean stocks built up during the 1980s has been overhanging the market. In spite of the reduction of stocks in the 1990s, overall stock levels remained high with the world stocks-to-grindings ratio remaining in the range of 45% to 65%. This prevented prices from responding more positively to reduced availability throughout the period.

- Secondly, consolidation and greater concentration in the cocoa trade and in the cocoa-processing industry, combined with developments in bulk transportation, information technology and communications, contributed to greater efficiencies in stock-management and a consequent reduction in industry demand for stocks.

- Thirdly, the continued upward trend in world production in leading cocoa-producing countries during the period, despite declining world prices, generated expectations of adequate world cocoa supplies over the short and medium term. Recent expansion of cocoa cultivation in new areas (Indonesia) and replanting with early-bearing, high-yield, hybrid varieties in traditional cocoa areas (Côte d'Ivoire, Ghana) was expected to lead to higher supplies, leading some market participants to re-assess the risk of future supply shortages, thus exerting further downward pressure on prices.

2.2. Consistency with ICCO Strategy for Cocoa Development

Cocoa is a commodity produced mainly in developing countries of the tropics and consumed mostly in the middle and high-income countries of the world's temperate zones. It generates a large international trade, which makes it a perfect product for international cooperation. More recently, structural changes attributed to the liberalization of marketing systems in West Africa were associated with two negative developments. The absence of appropriate marketing arrangements in place of central buying and quality control systems led to deterioration in quality in some countries, reducing premiums traditionally paid for West African cocoa. In addition, the abandonment of forward sales and increase in counter-party risks had a depressing effect on cocoa bean prices from this region. The cocoa economy is characterised by cyclical trends in supply and relatively steady growth in demand, and world cocoa prices have been highly volatile in recent years, ranging between USD 1,200 to USD 2,350 per tonne in the 12 months to February 2003. Intra-seasonal price fluctuations are primarily caused by changes in market expectations of supply and demand, fuelled by speculation. Following progressive deregulation and liberalisation of the cocoa sector all market agents, including farmers, are now fully exposed to price volatility on the world's terminal markets.

The project sought to reduce vulnerability of farmers to supply-side shocks and to perennial threats to production from pests and diseases; and to improve productivity, yield and quality, thereby reducing production costs and enhancing the economic returns derived from cocoa cultivation. In this respect, the project conformed to the ICCO's "Strategic Plan of Action for Cocoa" under the International Cocoa Agreement 2002. A major objective of international co-operation between cocoa producers on the one hand, and cocoa consumers on the other, has been, and continues to be, the avoidance of strong fluctuations in world cocoa bean prices caused by the boom-bust syndrome. On the production side, the ICCO strategy calls for direct co-operative action among cocoa producers to adjust world cocoa production, taking account of medium and long-term market trends and bearing in mind the basic aim of stable and remunerative prices that are consistent with high and rising levels of consumption. This would involve, among other things: an ability to control changes in production capacity within a reasonable time; measures to increase productivity and facilitate an orderly transfer of resources into and out of cocoa; direct exposure of production decisions to market forces; promotion of transparency in marketing arrangements; conservation and improvement of cocoa genetic materials; and defence of the competitiveness of cocoa *vis à vis* other crops, through quality improvement and stable prices. Overall, the main focus of the current global strategy for cocoa is on the need to increase the flexibility with which cocoa production responds to changes in price levels in both the short and long-term. If successful, it should contribute significantly to avoiding boom-bust cycles for cocoa and enhance the prospects for a prosperous world cocoa economy, facilitated by promoting greater market transparency, increasing productivity, reduction of production costs to enhance both the competitiveness of cocoa and farmers income, most of whom are smallholders.

2.3. Specific Value of the Project to Commodity Development

Besides the points highlighted in the sections above, it is expected that the availability and use of new cocoa varieties with increased productivity, resistance and quality will support specifically commodity development as follows:

- Improvement of competitiveness with regard to other crops, due to lower production costs and higher profitability;

- Improvement and increase in sustainability of cocoa production systems;

- Improvement of living standards for cocoa producers, mainly smallholders;

- Reduction of use of pesticides by use of more resistant varieties;

- An increased awareness of cocoa producing countries for the conservation of associated biodiversity in cocoa plantations;

- Increased collaboration between major stakeholders in the commodity: cocoa producers, national and international research institutions, extension services and chocolate manufacturers;

- Improvement of efficiency and increase in sustainability of cocoa breeding programmes through farmers' participation in selection and validation of new varieties, through increased availability of promising materials in collections and breeders' trials, and through increased capacity building.

2.4. Project Rationale

The main rationale behind the general project objectives include*:*

- Improvement of cocoa planting material has a specific and fundamental role to play to increase the efficiency and sustainability of cocoa cropping systems, to reduce production cost, to optimise use of natural resources and to improve cocoa bean quality;

- Breeding is often criticised for bringing adequate responses only in the long-term and sometimes not responding to the real needs of farmers. This 'drawback' received due consideration in the implemented project, as the activities provided useful results for farmers in the short-term and allowed for accelerated and sustained improvement of cocoa at the same time;

- Increased efficiency and sustainability in cocoa breeding is best obtained through direct involvement of cocoa farmers in selection and validation of new varieties and through increased international and regional collaboration, building on existing efforts. These two complementary approaches were basic elements of the implemented project.

The underlying rationale behind *Component 1 for "The distribution of promising planting materials to farmers and on-farm validation, through participatory selection"* included:

- The direct involvement of farmers in the cocoa selection process is necessary to speed up evaluation and use of new varieties under farmers' growing conditions;

- Prior to the project inception, there was a great shortage of tested superior varieties that could be recommended for large-scale distribution to farmers. Varieties with improved resistance and quality traits were especially required;

- Selection and validation of new cocoa varieties in farmers' fields (participatory selection) needed include on-farm testing of the best materials from breeding programmes with farmers' own selections, used commonly to establish new plantations;

- Identification of criteria used by farmers to select new varieties helps to guide existing breeding programmes;

- Analysis of selection criteria to be applied and decision taking on participatory selection procedures is best carried out by involving farmers, breeders and extension services. The project created adequate communication mechanisms to ensure knowledge sharing between these groups in all directions;

- The progress made in the CFC/ICCO/BIOVERSITY project on 'Cocoa Germplam Utilization and Conservation' justified validation in farmers' fields, as early as possible, of promising new selections;

- Evaluation of farmers' selections was also justified as such material may contain valuable sources for disease resistance (*e.g.* for witches' broom resistance in Brazil and Ecuador) and quality (Trinidad, Ecuador). Some of such selections have become widely distributed varieties (*e.g.* in Trinidad and Malaysia).

The underlying rationale behind *Component 2 for "The validation and distribution of promising varieties to farmers and to project partners through enhanced collaborative efforts"* included:

- Effective collaboration in cocoa variety improvement implies many partners, because of the regional nature of many production constraints (*e.g.* diseases and pests), since genetic diversity is largest in the Americas and use of cocoa largest in Africa and Asia, and because promising accessions can only be distributed through intermediate quarantine outside cocoa growing countries, and adaptation of selected cocoa varieties need to be verified locally;

- Due to the perennial nature of the cocoa crop, the collaborative efforts put in place by the CFC/ICCO/BIOVERSITY project on 'Cocoa Germplasm Utilization and Conservation' were only adequately exploited if the trials put in place (*e.g.* International and Local Clone Trials, population and germplasm improvement activities) were fully evaluated and if selected populations and accessions would effectively be distributed to user countries through intermediate quarantine;

- Important synergies could be developed between collaborative efforts (*e.g.* in the past CFC/ICCO/BIOVERSITY 'Germplasm Project') and other initiatives, such as disease resistance evaluations in the Americas; conservation of germplasm collections in Trinidad, Costa Rica and Ecuador; quarantine at Reading University, quality evaluations and use of molecular markers in cocoa (*e.g.* supported by USDA and by chocolate manufacturers associations). Such synergies were addressed through adequate co-financing arrangements proposed in the project;

- The destructive nature of the monilia disease, currently spreading in South and Central America, justified the involvement of CATIE (international research and education centre in Costa Rica) in the collaborative development of varieties with resistance to this disease;

- As observed in phase 1, the selection progress for resistance to witches' broom, monilia and cocoa mirids was still hindered by absence of reliable early screening methods. The development, validation and use of such methods could only be done through collaborative effort;

- Identification of stable associations over different environments between molecular markers and selection traits could only be carried out through international collaboration. Such was a prerequisite for future integration of DNA marker technologies into cocoa breeding and selection practices;

- In several countries, the lack of well-trained cocoa breeders and plant protection specialists is an important constraint to ensure sustainability of cocoa selection programmes. The project should promote human capacity building through exchange of scientists between project sites as well as through logistic support to more formal training of young scientists.

2.5. Specific Objectives

The *Overall Development Objective* of the project was to contribute to the welfare of the large number of smallholders cultivating cocoa through higher and sustainable productivity levels of good quality cocoa at lower production costs. The project was to contribute to this objective through selection, distribution and use of new cocoa varieties with improved yielding capacity, resistance and quality traits. Use of improved cocoa planting material should make cocoa cultivation more competitive and more attractive to new generations of cocoa farmers. It should facilitate diversification of cocoa-based farming systems by reducing land, labour and cash requirements for cocoa cultivation.

The *General Project Objectives* included:

(1) To validate promising cocoa varieties in farmers' fields through participatory approaches, involving farmers directly in the evaluation and selection process;

(2) To increase sustainability in cocoa crop improvement programmes through validation and dissemination of selected cocoa varieties between project partners, through enhanced regional and international collaborative research and development activities, and through capacity building;

(3) To exchange information and disseminate results among all project partners and also outside the project;

(4) To establish and maintain functional linkages between national cocoa breeding programmes, international cocoa genebanks and quarantine centres and international cocoa research and development efforts.

The *Specific Project Objectives*, within *General Objective (1)* included:

- To increase knowledge on planting materials present in farmers' fields and on approaches of farmers in choosing new planting materials, through farm-surveys carried out in all cocoa producing countries participating to the project;

- To identify promising planting materials in farmers' fields, based on knowledge of the farmers of their own planting materials and on selection criteria applied by farmers as well as by breeders;

- To preliminarily characterise and evaluate promising materials identified in farmers' fields through DNA analyses and through establishment of observation plots on research stations;

- To distribute to farmers and validate in farmers fields promising cocoa varieties identified in breeders trials with regard to best available farmers' materials;

- To strengthen the institutional linkages and knowledge sharing through participation of extension services and other stakeholders in 'National Stakeholder Meetings' and in annual 'Field Days', and through exchange of project personnel between project sites in the same region;

- To use opportunities for addressing concerns related to the management of genetic diversity in farmers' fields.

The *Specific Project Objectives* within *General Objective (2)* included*:*

- To exploit, through full evaluation and analyses, collaborative variety trails put in place in the CFC/ICCO/BIOVERSITY project on 'Cocoa Germplasm Utilization and Conservation';

- To validate the most promising varieties identified in the CFC/ICCO/BIOVERSITY project in national or regional on-station variety trials (some of these varieties will also be tested in the on-farm trials);

- To validate and disseminate to user countries' cocoa populations with enhanced resistance to *Phytophthora* pod rot, witches' broom and monilia;

- To distribute and establish accessions in user countries of the 'CFC/ICCO/BIOVERSITY Project Collection';

- To identify a more rapid and safe method for transfer of cocoa genes through the storage and shipment of healthy pollen;

- To accelerate selection for resistance to witches' broom, monilia and cocoa mirids through improvement and use of rapid early screening methods;

- To integrate information generated by molecular markers in cocoa variety selection and to avoid possible mis-identifications of project materials;

- To increase sustainability of cocoa breeding programmes through capacity building of project personnel.

The *Specific Project Objectives* within *General Objective* (*3)* included:

- To decide on general working procedures in the project (first workshop), mainly so for participatory selection and validation of new varieties;

- To carry out centralised analyses of results from collaborative activities involving more than one project site;

- To disseminate results through proceedings of the final project workshop, through specific publications and through introduction of data into databases.

The *Specific Project Objectives* within *General Objective (4)* included:

- To effectively coordinate project activities at general level, including collaborative research and development efforts, information and technology exchange and transfer of selected germplasm to user countries;

- To facilitate effective links between the conservation of cocoa germplasm and their use in breeding programmes and in farmers' fields.

2.6. Expected Outputs

Project Component 1: Distribution of Promising Planting Materials to Farmers and Validation On-Farm through a Participatory Approach

The aim of this component was to distribute and validate the best available planting materials through a participatory approach, with direct involvement of cocoa farmers. The participatory approach involves exchange of knowledge and of promising planting materials from breeders to farmers and from farmers' to breeders. The objective was to compare promising breeders' materials with planting materials on-farm and to disseminate the best of the materials by the end of the project. Activities were to be developed in all cocoa producing countries participating in the project, be it with variations that may be required to adapt to local situations and opportunities. The project partners in each of the cocoa producing countries (national research and development institutes) would have been the main coordinators for implementation of the activities, while involving extension services and other relevant stakeholders in the mutual knowledge sharing process concerning on-farm selection and use of new cocoa varieties.

Output 1.1: Survey of farmers' use and knowledge of planting materials

Only a minor part of planting materials used by farmers are bred varieties. The aim of this Output was to describe varieties currently used on farms and to identify criteria applied by farmers for choosing new planting materials. The most interesting trees in farmers' fields would then be collected and subsequently established in observation plots at research stations (Output 1.2) and in the on-farm trials (Output 1.3).

> ***Activity 1.1.1. Farm surveys:*** Farm surveys were to be carried out during the first semester in the first project year in all cocoa producing countries participating in the project. In total, the project aimed at surveying 2000 farms. The minimum number of farms proposed to be surveyed in one single country or in one major cocoa production area was 100. Analysis of data was carried out and results presented at the 'national stakeholder workshops' (see Output 1.4).

> ***Activity 1.1.2. Identification, description and collecting of promising planting materials in farmers' plantations**:* Promising planting materials in farmers' plantations were to be identified in all cocoa producing countries participating in the project according to selection criteria applied by farmers and researchers. Seed or budwood from in total 2000 interesting trees were to be established in nurseries at research stations, from where they should be multiplied and established in on-farm trials (Output 1.2) and in on-station observation plots (Output 1.3). The use of

farmers' selections in these trials was justified by the variation for yield, resistance or quality that can be found in most farmers' fields and by the fact that many cocoa farmers worldwide are using seeds from their own plantations or from their neighbours to create new plantings. More trees were to be selected in farmers' populations that present potentially useful genetic variation.

Output 1.2: Distribution of promising planting materials to farmers and validation on-farm

Best available breeders' selections were to be distributed to farmers to be compared with farmers' best planting materials in multilocation on-farm trials in all cocoa producing countries participating in the project. The project was to be complementary to any activity of similar nature that is already ongoing in a few countries. The breeders' selections included promising hybrids or clones identified in the CFC/ICCO/BIOVERSITY project on 'Cocoa Germplasm Utilization and Conservation, a Global approach'; as well as traditional standard varieties. The choice of planting materials to be tested in these trials depended on selection criteria (productivity, resistance, quality) identified by all stakeholders (see Activity 1.4.2).

Activity 1.2.1. Establishment of multi-location on-farm trials: The distribution and validation on-farm of promising planting materials was to be organised by the researchers involved in the project in close contact with extension services and farmers' organisations. The on-farm trials were to be initiated after procedures were established by the 'national stakeholders workshops' (see Activity 1.4.2). The project was expected to support establishment and evaluation of a total of 160 trial plots. The number and layout of trial plots per country (one to three) varied according to the value and characteristics of cocoa produced in different regions in the country and on expected useful variation present in farmers' fields.

Activity 1.2.2. Evaluation of planting materials on-farm: The main responsibility for establishing and maintenance of the on-farm trials lays with the farmers themselves. Researchers (breeders, agronomists) and extension services were involved in the establishment phase and in the observations subsequently to be carried out on the planting materials. The type of observations to be recorded (rate of establishment, early growth, yield, pest and disease incidence) was to be decided at the local stakeholders workshops and applied in a standardised manner over all trials in one country.

Activity 1.2.3. Further dissemination of planting materials to neighbouring farmers: As a result of the annual field days (see Output 1.4), interest was to be created among neighbouring farmers to establish the most promising selections in their own fields. Standard varieties selected by breeders' were to be provided by research stations to interested farmers in the course of the project. The project was to provide the technology to multiply and establish the most interesting clonal varieties from the on-farm plots in fields of interested neighbouring farmers. This 'natural dissemination' mechanism was expected to occur during the last few years of the project.

Output 1.3: Establishment and evaluation of farmers' selections on-station

All farmers' selections were to be established in observation plots at research stations. These plots would allow conserving the farmers' selections and carrying out preliminary characterisation and evaluation of these materials under more controlled conditions than in the on-farm trials (see Output 1.2).

Activity 1.3.1. Nursery multiplication and field planting of interesting planting materials collected in farmers' fields: Materials collected in farmers' fields and established in nurseries in Activity 1.1.2, were to be multiplied (in case of clones) and planted in so-called "Farmer Selections' Observation Plots (FSOP)" at research stations.

Activity 1.3.2. Preliminary evaluation of farmers' selections: Farmers' selections in all FSOPs were to be observed for vigour, precocity, pod production and disease or pest incidence. In countries where *Phytophthora* pod rot is important, early resistance screening tests (leaf tests and detached pod tests) were to be applied to the materials established in the FSOP.

Activity 1.3.3. Characterisation of interesting farmers' selections using molecular markers: This activity facilitated increased knowledge on the potential 'breeding value' of promising farmers' selections and the study of genetic relationships of these accessions with breeders' selections. Study of genetic diversity and level of heterozygosity of representative samples of planting materials established in FSOP's was to be carried out by using molecular markers (micro-satellites). Several hundred DNA analyses were to be carried out in the project, using 30 informative micro-satellite markers. This activity was mainly carried out through co-financing arrangements (see also Output 2.5).

Output 1.4: Stakeholder participation and capacity building

Participatory selection of cocoa varieties is a new type of activity in most cocoa producing countries. The aim of this Output was to share knowledge at national and international level, to involve other stakeholders and especially extension services, to decide on common aspects of the participatory approach to be applied in the project, and to adapt project objectives, where required, to the local conditions and opportunities. Knowledge sharing and exchange of information was to take place at national and international level, through organisation of workshops and exchange of project staff between project sites.

Activity 1.4.1. Knowledge sharing at national level: Project partners shouldorganise *National Stakeholders' Planning Workshops* involving farmers' organisations, extension services, research institutions, local industry and policy makers. These should normally take place after the farmers' surveys had been completed and aimed at discussing results from these surveys as well as decision taking on implementation of the on-farm trials.

Furthermore, *Annual Field Days* including farmers participating to the trials as well as neighbouring farmers, researchers and extensionists were to be organised by the local project coordinators for each trial. During these field days, possibilities were to be analysed to multiply and distribute the planting materials that generate interest to a larger number of farmers (Activity 1.2.3).

Activity 1.4.2. Knowledge sharing at international level: Optimal use will be made of existing knowledge on farmers' participatory selection approaches and on collection and preliminary evaluation of promising new planting materials. Discussions on participatory selection, evaluation and selection practices to be applied in the project were initiated during the initial project workshop, involving breeders and agronomists. An outside specialist on participatory selection approaches also participated in this meeting. Decisions were also to be made on common aspects to be standardised in the project.

Visits of national or institutional technical coordinators of the project and of other technical project staff were to be carried out between project sites in the same region to share experience and knowledge available among project partners.

Component 2: Validation and Dissemination of Promising Cocoa Varieties through Enhanced International Collaboration

The second project component aimed at validation and dissemination of promising cocoa varieties between project partners and to increase efficiency in selection of better cocoa varieties. Sustainability of national cocoa breeding programmes should be enhanced, enabling them to continuously provide better planting materials to farmers even beyond the duration of the project. Promising genotypes identified in the earlier CFC/ICCO/BIOVERSITY project on 'Cocoa Germplasm Utilization and Conservation, a Global Approach' were to be validated in local and/or regional variety trials. Early resistance screening methods were to be improved and stable associations between molecular markers and major selection traits (Quantitative Trait Loci or QTLs) identified to increase efficiency in selection of better varieties. These activities facilitate capacity building of project staff. Synergies were to be developed between CFC financed activities and collaborative efforts supported by co-financiers, such as disease resistance evaluations in the Americas; conservation and characterisation of germplasm collections in Trinidad, Costa Rica and Ecuador; quarantine at Reading University and Miami; evaluations of organoleptic quality; and, use of molecular markers for studies on genetic diversity and identification of QTLs.

Output 2.1: Selection and validation of varieties in ongoing collaborative trials

The main objective was to exploit promising new varieties identified in the collaborative trials put in place by the CFC/ICCO/BIOVERSITY project on '*Cocoa Germplasm Utilization and Conservation, a Global Approach*'. Screening for resistance to diseases and pests had already indicated presence of many promising materials in these trials. These were to be evaluated for other important traits (yield, vigour and quality) in this project and selected materials to be validated in new on-station observation and variety trials.

Activity 2.1.1. Evaluation and selection of established variety trials (80 ha): Two thousand five hundred accessions put in place in 80 ha of field trials in the CFC/ICCO/BIOVERSITY project on *Cocoa Germplasm Utilization and Conservation*, were to be evaluated for productivity, resistance and quality aspects.

Special attention was to be paid to the evaluation and analysis of the International Clone Trial, established at eight sites, which allowed analysing stability of selection traits over these sites and comparing 'international' with 'local' clones.

Activity 2.1.2. Validation of selected varieties on-station at national level (25 ha): The most interesting varieties selected in the collaborative trials (2.1.1) were to be validated in the on-farm trials (identified under Output 1.1.3). Other interesting selections from these trials were to be evaluated in observation plots or validation trials planted on station. In average three ha of new trials were expected to be established at each project site. This activity was partly supported by counterpart contributions.

Activity 2.1.3. Validation of resistant varieties at regional level (America and in Africa): A regional trial was to be established in six American countries in which 20 varieties with resistance to major diseases (monilia, witches' broom and *Ceratocystis*) were exchanged and evaluated. A similar trial was proposed to be established in four African countries, aiming mainly at resistance to *Phytophthora* pod rot resistance.

Output 2.2: Validation of germplasm enhanced for resistance to **Phytopthora** ***pod rot, witches' broom and monilia***

Populations with improved disease resistance were selected in Trinidad and in Costa Rica through collaborative efforts, including support from the CFC/ICCO/BIOVERSITY 'Germplasm' Project. These populations were based on genetic diversity present in the international cocoa collections in Trinidad (ICG,T, managed by the Cocoa Research Unit of the University of the West Indies) and in Costa Rica (collection managed by CATIE). In the current project, these populations were to be further evaluated to identify the most promising selections that should be made available to all interested project partners through international quarantine.

Activity 2.2.1. Germplasm enhancement for black pod resistance in Trinidad: The first cycle populations enhanced for *Phytophthora* pod rot resistance at the Cocoa Research Institute (CRU), with support of the CFC/ICCO/BIOVERSITY project on Cocoa Germplasm Utilization and Conservation, had already been established between 2000 and 2002 in observation trials. In the current project, approximately 1000 trees were to be evaluated for resistance to black pod (detached pod inoculations), resistance to witches' broom (mainly field evaluations) and for pod and bean traits. The best selections were to be transferred to international quarantine centres. Selected trees should be inter-crossed to evaluate the potential of a second cycle of selection by using early screening for pod rot resistance.

Activity 2.2.2. Evaluation and selection for witches' broom resistance in Trinidad: The best available early screening test for witches' broom resistance was to be applied to evaluate the most promising accessions in the ICG,T (as clones). Afterwards, crosses between the best accessions were to be tested aiming at accumulation of resistance genes in improved populations. Best selections were to be made available to international quarantine centres for distribution to user countries.

Activity 2.2.3. Germplasm enhancement for monilia and black pod resistance at CATIE: The international germplasm collection at CATIE has already been largely evaluated for resistance to monilia and black pod. Populations segregating for resistance to monilia and black pod were established in the field in the late 1990's. These materials were to befurther validated for resistance to monilia and to *Phytophthora* by applying appropriate resistance tests. Best selections are to be made available to international quarantine centres for distribution to user countries.

Output 2.3: Dissemination of collaboratively selected germplasm through intermediate quarantine to user countries

Selections made through collaborative efforts in the CFC/ICCO/BIOVERSITY project on *Cocoa Germplasm Utilization and Conservation* as well as in the current project were to be transferred through intermediate quarantine and established in interested user countries. Studies on use of pollen were proposed allowing for quicker and safe transfer of cocoa germplasm.

Activity 2.3.1. Quarantine and dissemination of selected accessions and progenies*:* Quarantine was to be carried out of clonal accessions that are part of the 'CFC/ICCO/BIOVERSITY Project Collection', of selections from the germplasm enhancement programmes in Trinidad and in Costa Rica (see Output 2.2), and of other promising selections made available between project partners.

Activity 2.3.2. Establishment of transferred germplasm in user countries: Accessions of the 'CFC/ICCO/BIOVERSITY Project Collection' and other selections made available between project partners were to be established in user countries.

Activity 2.3.3. Development of cocoa pollen conservation methods for safe and rapid transfer of cocoa germplasm: Studies on conservation and transfer of disease-free pollen were to be carried out in Trinidad. If successful, this method might be used for rapid transfer of cocoa genes from selected parental accessions (such as from enhanced germplasm populations).

Output 2.4: Improvement and use of rapid resistance screening methods

A serious constraint in cocoa evaluation and breeding activities has been the lack of rapid early resistance screening methods. The new project will help to improve resistance screening methods for witches' broom, monilia and cocoa mirids. . The project will develop and validate these methods,with regard to field data and, if successful, apply these methods to accelerate selection process in other project activities.

Activity 2.4.1. Early screening test for resistance to witches' broom and monilia: Alternative methods for early screening for resistance to witches' broom that are more efficient and less dependent on the environment were to be evaluated. Similar methods were tested for developing an early screening method for resistance to monilia. The best methods, were to be applied on the International Clones to verify stability of resistance and correlation with field results.

Activity 2.4.2. Early screening test for resistance to cocoa mirids: Resistance of cocoa varieties to *Calonectria*, a pathogen associated to mirid damage, could be a good indicator of tolerance to mirids. A *Calonectria* resistance screening method was to be developed and tested on the 'International Clones' to verify stability of resistance and correlation with field results.

Activity 2.4.3. Application of early resistance screening methods to select varieties in collaborative trials: Efficient and reliable early screening methods for disease and pest resistance, where available, were to be applied to accelerate evaluation of farmers materials (Output 1.3) and selection of new varieties in collaborative trials (Output 2.1.1).

Output 2.5: Identification of project materials with DNA markers and development of marker assisted selection

This Output dealt with two aspects of application of molecular markers in collaborative evaluation and selection trials. Firstly, molecular markers are potent tools to analyse possible mis-identifications of internationally distributed cocoa genotypes used in the project. Secondly, the project network enabled to identify stable associations between DNA markers and selection traits (Quantitative Trait Loci or QTLs) over a range of environments and in different genetic backgrounds. These are a prerequisite for application of marker-assisted selection (MAS) or for direct selection using molecular markers only, which allows increasing selection efficiency and accelerates the selection process. Emphasis in the project was to be on identification of QTLs related to disease and pest resistance. This Output was complementary to ongoing activities carried out by project partners on existing progenies. The molecular studies were to be carried out mainly through co-financing.

Activity 2.5.1. Verification of genetic identity of project materials: Microsatellite markers were to be used routinely in the project, to verify possible mistakes in multiplication and labelling of internationally or regionally distributed germplasm. It was expected that around 50 comparisons of DNA samples per year would be required.

Activity 2.5.2. Dissemination and evaluation of new elite segregating progenies: Five crosses between heterozygous parental genotypes with interesting traits (yield, resistance and quality) and with divers genetic background were to be produced. Two hundred and fifty seedlings of these crosses should be established at two different sites for phenotypic evaluations (other sites may request and receive also seedlings of these interesting progenies for use in breeding programmes). The chain design proposed makes it possible to analyse stability of QTLs over five sites and in different genetic backgrounds. The logistics of this activity will be supported through collaboration between national research institutes, co-financing institutions, and intermediate quarantine centres.

Activity 2.5.3. Identification of QTLs: Within the context of this project, such identification was proposed to be done for two progenies (those produced in Costa Rica and Ecuador). This activity was to be carried out mainly through co-financing by USDA and through counterpart contributions. .

Output 2.6: Exchange of project scientists between sites and training

Exchange of project scientists between sites in the same region and on-spot training was proposed to transfer rapidly new technologies, such as resistance screening methods and use of molecular markers in cocoa selection. These visits were also useful in support to coordination of regional activities (e.g. regional variety trials). Formal training of project scientists is required to increase sustainability of cocoa breeding programmes. Though the project would not provide scholarships directly, operational support was to be given to research activities relating to the project outputs in support of young scientists that were directly involved in the project. Needs for such training had been previously identified, among others, in Cameroon, Ecuador, Nigeria, PNG and Venezuela.

Activity 2.6.1. Exchange of scientists between project sites*:* For efficient transfer of technologies (resistance testing methods) and regional coordination of project activities (regional trials), around 12 trips of project personnel were to be made between project sites, as based on identified needs.

Activity 2.6.2. Operational support for formal training of young scientists: The project was to provide operational support for a number of young scientists or students (MSc or PhD level) from national institutions in cocoa producing countries involved in project activities and based on identified needs.

Component 3: Exchange of Information and Dissemination of Results

Planning and evaluation of results of project activities by all project partners was to be carried out through organisation of two project workshops. Data produced in the project should be analysed and results introduced into databases as well as published in international and local technical magazines. Project documents and related information would be circulated among project partners.

Output 3.1: Planning of project activities, analyses of data and dissemination of results

Activity 3.1.1. Project workshops*:* One project workshop was organised at the beginning of the project for planning of collaborative activities.. A second project workshop was planned at the end of the project, in which results were to be presented and disseminated in the form of workshop proceedings.

Activity 3.1.2. Analyses of data and publications: Data was to be analysed by the local implementing institutions. Data obtained from collaborative trials was to be analysed centrally.

Activity 3.1.3. Introduction of data into databases: Data on new cocoa varieties was to be introduced into international databases, *i.e.* mainly the International Cocoa Germplasm Database (ICGD) managed by the University of Reading, UK. This information is freely made available to all interested parties.

2.7. Expected Benefits and Targeted Beneficiaries

The selection and creation of varieties, both farmers' selected as well as institutionally improved, will continue to be of great benefit to the many smallholder cocoa growers in many countries. The participatory selection and validation approach used will lead to more sustainable systems of cocoa cultivation, to the use of less land for similar production levels of cocoa and to less losses due to diseases and pests. The potential decrease in the need for chemical pest and disease control resulting from cultivation of more resistant varieties should diminish environmental pollution, the risk of exposure of labourers to harmful pesticides and presence of residues.

The continuing active involvement of the farmers in the selection and validation process of new cocoa varieties will ensure that research results will directly benefit farmers, and that planting materials selected this way will be better adapted to the local farmers' conditions, exhibiting traits that the farmers need and want.

The project should also benefit the research community, especially the breeders, through:

- increased evaluation and breeding activities, which would not be possible or much more limited with counterpart funds only;

- increased availability of valuable genetic diversity through distribution of selected genotypes;

- use of farmers' knowledge and access to materials selected on farms in breeding programmes;

- availability of new resistance screening tests;

- increased collaboration among cocoa producing countries as well as between these countries and international germplasm and quarantine centres.

Intensified and improved international contacts are expected to facilitate access to the conserved germplasm and thus to strengthen indirectly the operations and the sustainability of the National and International Cocoa Genebanks. Furthermore, the international co-operation will enhance the efficiency of the conservation of cocoa germplasm at national and international levels, through increased use and distribution of genotypes from these collections. It is hoped that this will create conditions leading to more sustainable management and funding of these collections.

In conclusion, as a result of this project current indications suggest that all participating cocoa producing countries should be able to incorporate broader genetic diversity into their improvement programmes and, thereby encourage more productive and environmentally-friendly cultivation practices of cocoa. Consumers of cocoa products will benefit through more stable access to products at affordable prices and of better quality.

In general terms, the project would be embedded mainly in existing local and national structures. The activities of Component 1 (participatory selection and validation of new varieties) are expected to be sustainable as these are carried out directly by farmers or in collaboration with farmers. It was expected that selected materials of interest to farmers will be used on a larger scale by these farmers and by their neighbours as the results of the on-farm trials have become visible, already within the duration of the project and will continue to be used also afterwards. The transfer of technologies, selected genotypes and human capacity building, as envisaged in Component 2 of the project (collaborative breeding efforts on-station), are in direct support to the efficiency and sustainability of national breeding programmes. The approach taken regarding the coordination of the project is sustainable in that the efforts do not lead to "scientific dependency" but, on the contrary, that they will strengthen the local/national capacity and of the evolving institutional frameworks. The aforementioned principles are expected to lead to little, if any, long-term dependency from outside funding.

Through the strengthening of the informal global network of cocoa, the established contacts between scientists are likely to continue beyond the project lifespan and information and germplasm will continue to be exchanged through this channel. Finally, by strictly following the formal procedures of obtaining guarantees of full commitments regarding the planned inputs of financial, human and other resources by the various partner institutions and/or the corresponding governmental authorities it appeared that the project was built on a solid foundation. The latter has been further strengthened through the official procedures of the Commodity Body thus securing the necessary political backing for the project.

2.8. Project Costs and Financing Plan

The total project cost was originally estimated at USD 10,504,553, of which USD 3,916,120 has been allocated by the Common Fund for Commodities as a grant. The following amounts of Co-financing and counterpart financing were agreed upon with the co-financiers and with the collaborating institutions.

Amount of *Co-financing*	USD 3,338,443 of which:	
	CRA	USD 427,000
	CIRAD	USD 1,100,000
	Guittard	USD 69,943
	Mars Inc.	USD 100,000
	USDA	USD 1,025,000
	WCF	USD 616,500
Counterpart contributions	USD 3,249,990 of which:	
	Bioversity International	USD 700,000
	CATIE	USD 95,000
	CCI	USD 220,220
	CEPLAC	USD 256,500
	CNRA	USD 273,000
	CRIG	USD 302,000
	CRIN	USD 175,000
	CRU	USD 350,000
	INIA	USD 142,500
	INIAP	USD 211,800
	IRAD	USD 125,800
	MALMR	USD 143,870
	MCB	USD 174,900
	UNAS	USD 64,400
	University of Reading	USD 15,000

2.9. Management and Implementation Arrangements

Overall management of the project has been carried out by CFC and by the Supervisory Body (SB) in collaboration with the Project Executing Agency (PEA). The mid-term evaluation process of the project was to be organised by the PEA, in close consultation with the CFC and with the SB. The SB has had an active role in the development and presentation of the project proposal to CFC. The SB also supervises the implementation of the project and participates in the mid-term evaluation procedure.

Arrangements put in place by Bioversity International included the establishment of a Coordination Unit in Montpellier, France. This Unit had to provide effective liaison between all project partners and was in charge of:

- Organisation of the two project workshops (year 1 and year 5);
- Participation in the elaboration of general project documents. Establishment of Project Implementation Agreements (PIA) and of annual Letters of Agreement (LOA) between the PEA and all project partners;
- Regular visits of the project co-ordinator to the project sites, according to requirements, and elaboration of travel reports;
- Organisation of Regional Project Meetings, two in Africa and two in the Americas, in year 2 and in year 4;

- Elaboration of general progress and financial reports;
- Analyses of progress and financial reports, and distribution of project results and documents to all partners;
- Organisation of annual financial audits;
- Presentation of the project at international meetings and publications on the project in magazines;
- Coordination of exchange of information and germplasm as well as of analyses of common project results.

3. PROJECT IMPLEMENTATION AND RESULTS

3.1. Resource Utilisation

The resources utilisation is reflected in Tables 1, 2 and 3.

Table 1 shows the modifications accepted by CFC in the budgets for the project partners that have been affected by fluctuations in exchange rate, by increased operational costs or by additional activities. The total amount of accepted modifications was US$167,311 According to the negotiations with CFC, these funds are to be considered as payable from the Contingencies (total amount of US$186,482).

Table 2 shows the utilisation of CFC project funds by project sites. The Table reflects the situation as of April 2010, when most of the project activities had been terminated. The Table does not include the costs of the Final Workshop of the project, neither the costs of the Final Project Publication. These will be presented in the final financial statement. As shown in Table 2, total expenditure have been 93% of available resources. Most project sites had spent approximately 100% of the available resources. One project site (MCB, Malaysia) has spent more than available, indicating an increase in the MCB counterpart contribution. Other sites have spent less than funds available. The lowest level of spending was observed at MALMR, Trinidad (63%) followed by INIA, Venezuela (81%). The reasons for such under-spending were mainly administrative.

Table 3 shows the estimated utilisation of counterpart and co-financing resources. In total, the counterpart expenses exceeded the amount budgeted by 15%. Project partners that overspent more than 30% of the budgeted amount were CATIE (Costa Rica), CEPLAC (Brazil), IRAD (Cameroon), MALMR (Trinidad) and MCB (Malaysia). The co-financing contributions were estimated to have been 13% higher than budgeted. This demonstrates the commitment of the co-financiers throughout the project duration. The individual contributions varied from 76% to 187%.

Table 1. Modifications of CFC budget allocations due to exchange rate fluctuations or to increased operational costs*

COST SITE	Period	Budget without compensation	Compensation applied (%)	Amount compensated (US$)	Adjusted budget (US$)
Compensations provided (Year 1- 4)					
IRAD (Cameroon) [1]	Year 1	71,100	19.2	13,649	84,749
	Year 2	25,050	21.9	5,487	30,537
	Year 3	23,400	28.1	6,568	29,968
	Year 4	23,850	30.0	7,155	31,005
	Year 5	22,350	50.0	11,175	33,525
CRIN (Nigeria) [2]	Year 3	17,400	28.7	5,000	22,400
	Year 4	17,400	30.0	5,220	22,620
	Year 5	8,700	30.0	2,610	11,310
INIAP (Ecuador) [2]	Year 3	23,600	30.0	7,080	30,680
	Year 4	28,050	30.0	8,415	36,465
	Year 5	21,150	30.0	6,345	27,495
UNAS (Peru) [3]	Year 4	6,486	77.1	5,000	11,486
	Year 5	2,493	100.0	2,493	4,986
CNRA (Côte d'Ivoire) [1]	Year 4	41,000	30.0	12,300	53,300
	Year 5	36,600	50.0	18,300	54,900
CCI (PNG) [2]	Year 4	25,745	30.0	7,724	33,469
	Year 5	25,155	30.0	7,547	32,702
MCB (Malaysia) [2]	Year 4	37,239	30.0	11,172	48,411
	Year 5	30,237	30 0	9,071	39,308
CEPLAC (Brazil) [1]	Year 5	38,425	39.04	15,000	53,425
Total		525,430		167,311	692,741
Total Contingencies available				186,482	

[1] For exchange rate fluctuations
[2] For increased operational costs
[3] For additional activities

** Bioversity International certified financial reporting occurs under separate cover*

Table 2. CFC resource allocation and utilisation by cost site for 66 months (in US$) **

Cost Site	Original budget 60 months***	Corrected budget 60 months*	Expenses at cost sites 66 months	Expenses made in Montpellier	Total expenses 66 months	Budget spent (% of 60 months)
CATIE (Costa Rica)	112,250	112,250	112,250	0	112,250	100%
CCI (PNG) *	178,803	191,748	175,305	2,326	177,631	93%
CEPEC/CEPLAC (Brazil)	225,030	240,030	234,851	263	235,114	98%
CNRA (Côte d'Ivoire) *	225,000	255,600	246,438	9,936	256,374	100%
CRIG (Ghana)	245,020	245,020	245,054	0	245,054	100%
CRIN (Nigeria) *	115,000	127,830	117,332	344	117,676	92%
CRU (Trinidad)	283,000	283,000	284,038	0	284,038	100%
INIA (Venezuela)	157,610	157,610	132,015	0	132,015	84%
INIAP (Ecuador) *	165,050	186,890	188,834	0	188,834	101%
Bioversity (Italy, France)****	1,318,000	1,318,000	1,149,621	-18,136	1,131,484	86%
IRAD (Cameroon) *	155,750	199,784	194,203	5,267	199,470	100%
MALMR (Trinidad)	100,011	100,011	62,887	0	62,887	63%
MCB (Malaysia) *	155,002	175,244	193,017	0	193,017	110%
UNAS (Peru) *	54,364	64,350	59,357	0	59,357	92%
University of Reading (UK)	99,750	99,750	99,734	0	99,734	100%
TOTAL	**3,589,640**	**3,757,117**	**3,494,936**	**0**	**3,494,936**	**93%**

* Includes a compensation for the US$ depreciation in relation to the local currency over the 5 year period or for increased operational costs. These corrections have been paid for from the Contingencies.

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*** Not including Contingencies

**** Excluding expenses for the final project workshop, final publication and data analyses

Table 3. Counterpart (A) and co-financing (B) contributions and total project funding (C) for Year 1 to Year 5 **

Type of financing	Budgeted amount 60 months	Reported expenses 66 months	Percentage spent of budgeted amount
A. COUNTERPART:			
CATIE (Costa Rica)	95,000	125,022	132%
CCI (PNG)	220,220	225,280	102%
CEPEC/CEPLAC (Brazil)	256,500	334,906	131%
CNRA (Côte d'Ivoire)	273,000	268,209	98%
CRIG (Ghana)	302,000	354,600	117%
CRIN (Nigeria)	175,000	182,648	104%
CRU (Trinidad)	350,000	383,825	110%
INIA (Venezuela)	142,500	156,750	110%
INIAP (Ecuador)	211,800	204,638	97%
Bioversity (Italy, France)	700,000	800,000	114%
IRAD (Cameroon)	125,800	173,051	138%
MALMR (Trinidad)	143,870	186,722	130%
MCB (Malaysia)	174,900	248,357	142%
UNAS (Peru)	64,400	64,400	100%
University of Reading (UK)	15,000	15,000	100%
TOTAL COUNTERPART	**3,249,990**	**3,723,408**	**115%**
B. CO-FINANCING:			
CRA	427,000	482,111	113%
CIRAD	1,100,000	1,386,000	126%
Guittard	69,943	53,440	76%
Mars Inc.	100,000	187,636	187%
USDA	1,025,000	1,198,171	117%
WCF	616,500	467,050	76%
TOTAL CO-FINANCING	**3,338,443**	**3,774,408**	**113%**
C. TOTAL EXPENSES BY FUNDING SOURCE:			
CFC funding *	3,589,640	3,494,936	93%
Counterpart	3,249,990	3,723,408	115%
Co-financing	3,338,443	3,774,408	113%
TOTAL FOR PROJECT	**10,178,073**	**10,992,752**	**108%**

* Excluding Contingencies, Supervision and Management Costs
**Bioversity International certified financial reporting occurs under separate cover

3.2. Summary of Project Results

Project results as related to the planned Outputs and Activities identified in the PIA for the five-year period are described in detail in Annex 1. Most activities have been carried out as planned. Most were successfully implemented, be it sometimes with delay. Few activities have not yielded the expected results.

3.2.1. Component 1. Participatory approaches to cocoa selection and breeding

Approximately 2000 farms were surveyed in ten different countries. The knowledge of the farmers on their planting materials was documented and results were presented at international cocoa meetings (*e.g*. INGENIC 2006 Workshop). As planned, approximately 2000 trees were identified as interesting for yield or for low disease or pest incidence. Early screening for Ppr resistance carried out in Africa and in Trinidad showed that several of the farmers' selections were highly resistant to the disease. This was in agreement with farmers' knowledge on trees that were identified as less susceptible in farmer's fields (Efombagn *et al*., 2007, Pokou *et al*., 2008).

Approximately 1,500 farm selections were established in on-station observation plots or in on-farm trial plots in eight countries. Evaluation of these farm selections has been initiated. Some farm selections appear to be as good as or better than the local control varieties. Through a co-financing agreement, including with the IITA, the genetic diversity of approximately 2000 farm selections in Africa was analysed using SSR markers. The results show large genetic variation in the farm population, which is mainly of hybrid origin, with important contributions of the Amelonado, Trinitario and Upper Amazon parental genomes (*e.g*. Efombagn *et al.,* 2008).

Approximately 240 on-farm selection plots were established with support of the project (originally 200 were planned). In most of these plots, varieties selected by breeders' are being compared to farm selections (clones or seedling progenies). This activity suffered from drought in Africa and from neglect of some of the farmers. Consequently, the total number of plots that are still actively being observed has therefore been reduced to approximately 120 150 plots.

3.2.2. Component 2. Collaborative approaches in cocoa breeding

3.2.2.1. Evaluation and selection of variety trials established in the "Germplasm" project

Approximately 85 ha of variety trials established in the Germplasm project (ICCO/02) have been evaluated throughout the current project. In several countries (*e.g*. Brazil, Ghana, Nigeria, Trinidad and Tobago and Papua New Guinea) several new varieties were selected or confirmed for commercial distribution to farmers. Numerous promising individual trees or hybrid varieties were selected to be used in further confirmation trials in several other places (*e.g.* Venezuela, Ecuador, Brazil and Côte d'Ivoire). Establishment of new variety trials with promising selections was carried out in Ecuador, Brazil, Côte d'Ivoire, Malaysia and Papua New Guinea.

The International Clone Trial, established in eight countries, has also been evaluated throughout the second project. Although some clones yielded quite well, in general the average of the local control clones, evaluated in the Local Clone Trial, yielded substantially more than the average of the International Clones. This shows the low level of adaptation of many of the International Clones, which were not previously selected for yield potential. However, some of the International Clones out-yielded the local control clones at a few sites. Evaluation of sensory quality was carried out for the International Clones during 2007-2009. Cocoa liquors of approximately 200 cocoa bean samples were prepared and distributed by Guittard Chocolate Co. to three panels (CIRAD, CRU and Guittard/Mars Inc.). Data analyses showed significant environmental effects for cocoa flavour, acidity and astringency and clone effects for floral flavour. Interactions between environment and clones estimated over two years of evaluations were not significant, whereas significant effects were obtained for individual years. Significant differences between clones were also observed for agronomic traits at all sites. Yield data appeared to be significantly correlated over a large number of sites, while vigour was less well correlated between sites. Physiological traits varied over sites and clones reacted variably suggesting that different genotypes require different management practices (such as pruning) to optimise yield performance.

3.2.2.2. Regional Variety Trials (RVT)

The project supported the establishment, between 2005 and 2006, of a RVT in the Americas (6 countries) and of another RVT in Africa (4 countries). The objective was to exchange hybrid varieties with good yield potential and with resistance to diseases (Ppr, monilia and witches' broom). The first results in Costa Rica show significant variation in resistance to monilia (10-50% infection), with two hybrids having very low infection levels.

3.2.2.3. Germplasm Enhancement for disease resistance

A large Germplasm Enhancement programme for resistance to Ppr has been implemented at CRU already from the 1998 onwards. Interesting results were observed for the Ppr resistance enhancement, obtaining approximately 70% of resistant (R) or moderately resistant (MR) trees after one cycle of selection of crosses among selected parental accessions of the IGC,T. The original population only contained 30% of MR or R trees. CRU already initiated the second cycle, *i.e.* selection of seedlings from crosses between first cycle selections. A similar enhancement programme for resistance to witches' broom was initiated in 2004. Approximately 5000 seedlings were evaluated and 200 selected seedlings (also tested for resistance to Ppr) were planted in the field for further observations.

3.2.2.4. Quarantine and distribution of selected accessions

The so-called, "CFC/ICCO/Bioversity Collection" was selected as part of the first project activities. This collection contains 112 accessions mainly selected from the ICG,T for resistance to Ppr, but it contains also selections with resistance to witches' broom and to monilia. During the current project, this collection was sent to the Reading University intermediate quarantine facility, where it underwent virus indexing for a two year period. At the end of the project, 80 clones had completed quarantine. Distribution of this collection has been initiated, especially to African countries.

3.2.2.5. Resistance testing methods

The use of the leaf disc and pod test for Ppr resistance screening was validated during the second project in Côte d'Ivoire and in Cameroon.

Screening for resistance to witches broom with the traditional spray method appeared less consistent at individual plant level. In Trinidad, good results were reported by using the agar droplet method, aiming at high infection level and evaluation of the broom base diameter as the main selection trait. This method was since adopted in the germplasm enhancement programme. Pod inoculations were tried but infection levels were low or inconsistent. More work will be required to improve this method.

Early screening for resistance to monilia by inoculation of seeds or young seedlings failed to produce symptoms. The pod inoculation method in the field proved to be reliable, and this was used successfully in Costa Rica as well as in Ecuador.

Testing of antixenosis (choice of insect to feed on twigs from different cocoa genotypes), tolerance and antibiosis (capacity to survive on different host tissues) to cocoa mirids showed often inconsistent results and these methods are laborious to be carried out. However, antixenosis appeared to be related to long-term damage of mirids observed in Côte d'Ivoire. *Lasiodiplodia* was easily isolated from young and old mirid wounds, showing a possible association with mirid damage. Screening methods for *Lasiodiplodia* resistance were tested using *Lasiodiplodia* inoculations of wounded seedlings and detached twigs. Results were inconsistent, including when artificial wounding was used as a method to facilitate natural infection with *Lasiodiplodia.*

3.2.3. Component 3. Exchange of information

Four regional workshops were organised between 2005 and 2007, two in the Americas (Venezuela and Ecuador) and two in Africa (Cameroon and Côte d'Ivoire). A final workshop of the project was held in Accra from 31 May to 4 June 2010. Presentations and conclusions of these workshops were distributed on Cd-Roms. So far, 86 articles were published including results from the project (see Annex 2).

3.3. Main Benefits Achieved

- Reinforcement of existing cocoa breeding programmes in 11 countries.
- Selection of 55 new candidate varieties for distribution to farmers in Brazil, Ecuador, Trinidad, Nigeria and PNG.
- Selection of numerous varieties to be used in further breeding (all cocoa producing countries).
- Adoption of a farmers' participatory approach in cocoa breeding through capturing farmers' knowledge on their planning materials, through selection of interesting trees and establishment of on-farm trial plots.
- Establishment of two Regional Variety Trials in six countries in the Americas and in four countries in Africa, aiming at sharing of varieties with disease resistance.
- Evaluation of stability of cocoa traits through the International Clone Trial, using similar evaluation methods.
- Insight has been gained into resistance testing methods. Positive results were obtained with testing for Ppr resistance methods, whereas less consistent results were obtained with methods used for other diseases and pests.

- Use of the Trinidad germplasm collection to carry out pre-breeding for resistance to *Phytophthora* pod rot and to witches' broom disease.
- Initiation of distribution of germplasm selected in the project through quarantine at the Reading University to user countries, especially African countries.
- Unprecedented co-operation was achieved among research institutions in the cocoa producing countries, regional and international institutions, and the private sector.

3.4. Impact

3.4.1. Technical

The following technical impact factors can be identified:

- Better planting material for farmers has been selected. In a few countries (Brazil, Trinidad, Nigeria, Papua New Guinea), approximately 55 new candidate varieties for distribution to farmers were identified.
- The project has positively impacted on cocoa breeding programmes, through reinforcement of ongoing breeding programmes.
- A total of 1500 promising trees were identified by using a farmers' participatory approach.
- More than 100 selected genotypes were quarantined and distribution to user countries initiated.

3.4.2. Institutional and capacity building.

- Human capacity building was achieved through the organisation of four regional workshops and exchange of results (publications, project reports).
- The data generated in the project were used to obtain three PhD degrees in Africa, and several MSc and undergraduate degrees elsewhere.
- As a spin-off of the project, institutes have managed to obtain new projects in cocoa breeding and also in other cocoa research areas.

3.5. Dissemination of Project Results

- Results have been disseminated among the project partners in the bi-annual reports of the project.
- Four Regional Project Workshops were organised, two in the Americas and two in Africa. During these workshops results were presented and discussed. CD-Roms with the presentations and with the Conclusions and Recommendations were distributed to all participants.
- Final results were presented at the Final Workshop of the project that was held in Accra on 31 May until 4 June 2010. A CD-Rom was produced with all presentations and with the Conclusions and Perspectives and was distributed to the participants of the workshop.
- So far, a total of 86 articles using project results were published (see Annex 2) in scientific magazines, Proceedings, Newsletters, Annual Reports, as BSc theses, *etc.*

4. LESSONS LEARNED

4.1. Development Lessons

- Lack of motivation of farmers participating in the on-farm trials has been one of the reasons (besides drought) why several of the on-farm trial plots had to be abandoned. In future trials it is therefore of paramount importance that the farmers be selected for their real interest in participating in such trials. It is also important to explore ways of motivation of the farmers and involve the extension service at an early stage to make this activity more self-sustainable.
- In Brazil, grafting on basal sprouts (chupons) of adult cocoa trees has been used for establishment of on-farm trials. Because of irregular chupon formation, this has resulted in large within-clone variation in these trials. It is recommended to use seedling grafting and planting of the grafted seedling in-between the old cocoa rows to obtain more regular stands.
- The development of an early screening test for resistance to monilia (*Moniliophthora roreri*) was tried at three of the project sites. All the methods tried failed as the fungus did not show any symptoms on young vegetative tissues of cocoa seedlings. Evaluation of resistance to this fungus will therefore depend on inoculation of pods in the field and on observations of natural infection in the field.
- Alternative methods for early screening of resistance to witches' broom disease (*M. perniciosa*) of cocoa progenies were tested in Brazil, Ecuador and Trinidad. The agar-droplet method has given reliable results in Trinidad, whereas this method did not have advantages over the belt-spray method in Brazil and Ecuador. The main difficulty appeared to be that the broom base diameter is difficult to measure in Brazil and Ecuador, due to the differences in symptom expression of the disease between Brazil and Ecuador in relation to Trinidad. The breeder will therefore depend on the belt spray method which can provide reliable results at the level of average resistance of seedling families. For evaluation of individual plant resistance, the methods to be used are observations on natural infection in the field. Observations can be speeded up by inter-planting of seedlings between old cocoa rows with high natural infection rate. The latter method has been adopted in Ecuador, to obtain rapid results on individual seedling resistance to witches' broom.

4.2. Operational Lessons

- The project had a very complex operational system, with 14 collaborating institutions over 12 different countries. The creation of a Coordination Unit by Bioversity International in Montpellier was fundamental in effective coordination of the project. Regular visits of the Project Coordinator to all partners were also of basic importance to exchange information and coordinate common project activities. Coordination was facilitated thanks to the commitment of all the project partners to deliver their results and the reports in time.
- Some countries were late in signing of the PIA. These countries have used their own funding (counterpart funding) to carry out a minimum of activities until CFC funding was obtained.
- Several countries suffered from unfavourable exchange rate fluctuations, so that for the same USD value less money in local currency was obtained. In other countries the operational costs had increased substantially in USD terms, decreasing the purchasing

power of the USD budget. It has been very important that CFC allowed using the larger part of the Contingencies to compensate for part of these losses, so that most of the activities could be carried out according to plans.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. General conclusions and recommendations

The CFC/ICCO/Bioversity project has shown the feasibility to collaborate in cocoa breeding through the use of similar approaches and exchange of information. The farmers' participatory approach applied in the project has allowed for the farmers to be involved directly in the selection of new varieties. In the on-farm trials breeders' selections are being compared to farm selections. This way it is hoped that the farmers adopt the best materials as shown in their own conditions.

At all sites, numerous clone and hybrid varieties were selected for further use in breeding. In four countries new candidate varieties were selected that can be recommended for distribution to farmers. Approximately 1500 promising farm selections are being compared with the best breeders' selections in on-station observation trials and in the on-farm variety trials. Genetic diversity of more than 2000 farm selections in Africa was analysed through co-financing arrangements and results published. Numerous varieties with high levels of resistance to major diseases (*Phytophthora* pod rot or Ppr, witches' broom and moniliasis) were selected in the pre-breeding programmes carried out in the international cocoa germplasm collections held by CRU and CATIE as well as in cocoa producing countries. Transfer of selected germplasm to interested user countries, through intermediate quarantine at Reading University, has been initiated.

Rapid and/or early resistance screening methods have been validated and successfully adopted for Ppr, while screening for resistance to other diseases and pests continues to rely mainly on field evaluations. The International Clone Trial (ICT), planted at eight sites, has yielded important information on stability of agronomic, diseases resistance, physiologic and quality traits. The relative stability of these traits over sites suggests that evaluations made at one site will be of value also at other sites. This underpins the value of collaborative approaches in cocoa breeding, *e.g.* such as the germplasm evaluation and enhancement programmes carried out in Trinidad and in Costa Rica.

Resource utilisation has been within the limits of the CFC budget. Co-financing and counterpart contributions exceeded the planned contributions at the onset of the project. This shows the continuous commitment of the co-financiers and of the collaborating institutions.

Several of the activities initiated in the project are still ongoing. Such is the case for the on-farm trials and for the Regional Variety Trials. It is expected that these trials can be continued within the local breeding programmes. New collaborative initiatives are however required to continue with the pre-breeding programmes and with the distribution of selected materials. The distribution of accessions with resistance to monilia and to witches' broom to Africa should continue to be a major objective. Major constraints in cocoa production, such as destructive diseases and pests, vary between the regions (continents). Therefore, continued regional cooperation would be of great value in overcoming these constraints.

5.2. Specific conclusions and recommendations

The following specific conclusions and recommendations were reached at the final workshop of the project for each of the following topics (sessions).

5.2.1. Farm surveys and collection of interesting selections

- Often mixtures of traditional and improved varieties are found in farmers' fields.
- The surveys revealed that many farmers are ageing as well as farmers' plantations.
- Farmers are able to identify materials by characteristics (yield, resistance and pod/bean characteristics).
- Some preference for "traditional"/own material with regard to black pod incidence was observed.
- Many farmers are willing to accept (and some to pay for) improved types looking for yield, disease/pest resistance and pod/bean characteristics.
- It is essential for breeders to interact more with farmers to understand farmers' needs and growing conditions.
- Farmers' knowledge and material can be useful for research (*e.g.* farmer selections for black pod correlated with leaf disk screening).
- Knowledge of farmers is based mostly on observation of individual trees, though some have the ability to identify varieties based on pod characteristics.
- Due to low heritability of traits from single tree selections, further evaluation is essential to assess true genetic potential
- Farmer field conditions are different from research station (environment & inputs). This is to be taken into account when assessing farmers' materials.
- The potential of improved materials on farm is often not being realised due to low inputs/poor management and different biotic/abiotic stresses (climate, diseases...).
- Farmers need training and/or inputs to fully exploit potential. This can be achieved by setting up demonstration plots and/or providing inputs, such as fertilizers.
- Though it is important that breeders' trials reflect current farmer practices and constraints, it is also important to take future developments into account: *i.e.* intensive *vs.* extensive production, fertilizer/agrochemical usage, clonal *vs.* seedling varieties, adequate planting densities, climate change scenarios, and rootstock and pollination compatibility.
- The surveys indicated variation in availability of improved varieties, partly due to the proximity of seed gardens.
- There is a need to develop technology for clonal gardens, especially in West Africa.
- The potential/economics of new technologies *e.g.* tissue culture as a means to distribute new varieties needs to be established.
- Consideration is to be given to mixtures of clones supplied at farm and region level.
- Farmers' have agreed to make their materials available to other farmers in the current project. However, intellectual property rights (IPR) including farmers' rights with regard to farm accessions has to be given further attention.

5.2.2. On-farm trials established and evaluated

- Farmers' selections can perform as good as or even better than improved varieties, and thus could be used in breeding activities.
- On-farm trials are positive but not always easily conducted.

- Expectations for farmers and scientists roles should be made clear from the beginning of the project and scientists should stay in regular contact with farmers.
- The combination of on-farm trials with farmers' capacity building is recommended.
- The involvement of extension officers is recommended in all the steps of the on-farm trials for more efficiency.
- The methodology should be simplified and adapted to the farmers' skill.
- The selection of key farmers is recommended.
- The simplified method based on the counting of pods at the beginning of the main harvest season on the cacao tree would be a more adapted alternative method for evaluating yields on-farm.
- The use of fertilizer in on-farm trials is recommended, but there is a need to provide funds in the initial budget.
- The distance between the farmers' farms and the research station can be a real constraint.
- The lack of chupons, and of uniformity of chupons, is a constraint to the basal chupon grafting technique, increasing within-clone variation.
- Collaboration between breeders and the other specialists (agronomist, pathologists, entomologists *etc*) is recommended.

Perspectives

- Continue data collection in the various trials, taking into account resistance to insects and diseases, pod and bean characteristics, as well as fat content.
- Promising cultivars should be established in demonstration plots to validate their performance to farmers
- Demonstrations plots could be linked to a multiplication effort according to the type of planting material to be distributed
- Development of extension materials should be tailored to local needs

5.2.3. Molecular marker studies of farm accessions

- High incidence was observed of non true-to-type improved planting material in farmers fields (traditional germplasm have been replaced by planting material with improved origins).
- Diversity among farm accessions is largely comprised within the diversity used by breeders and is different among countries.
- Diversity in gene banks is low proportionally to the existing accessible diversity available in the species.
- Since a low number of reference clones were used in these studies, it appears to be a differentiation between Upper and Lower Amazon clones. This is due to the fact that traditional cultivars are much less diverse. It is necessary to be more specific when referring to genetic backgrounds. Use of the new classification will help.
- It was proposed to integrate the farmers' accessions data for a study combing all the four data sets presented.
- Efforts are being made using molecular markers to identify cultivars that could be marketed according to their genetic and geographic origin (Ecuador). This could create added value. The new classification could help in this direction.

- Preventive breeding for moniliasis and WB resistance seems to be an important concern. Two approaches were discussed: MAS and the introduction of resistant parents, MAS was preferred by some participants as the safest approach.
- Concerns were expressed about funding to characterize the four mapping populations established in the project (in Costa Rica, Côte d'Ivoire and Ghana). It was clarified that the current agreements with the institutions concerned should cover the costs of the evaluations.
- The new SNP technology should allow to shortly map the remaining mapping populations.
- This technology should also improve the rate of application of the molecular biology research.
- It was proposed to have a specific meeting on preventive breeding.
- There was discussion about how to explore the value of the germplasm. Clone evaluations were proposed instead of test crosses, but it was clarified that clones such as those from French Guiana (GU) do not show much value as clones but have been demonstrated to be good parents for yield.

5.2.4. Comparative analyses of the international clone trial (ICT) results

- While genetic diversity representation and black pod resistance were the main selection criteria at the time of composing the clones for the ICT, it was agreed that yield aspects as well as resistance to other diseases should be considered for future trials.
- The selection of clones for future trials should include considerations under which environmental conditions the performances of clones are to be evaluated.
- The need to include agroclimatic, management practices and soil data along with the evaluation data has been stressed in order to allow a better interpretation of the results.
- Bigger elementary plots per clone could be an improvement.
- The indications that yield plasticity has a significant genetic basis should be confirmed.
- Plant density has been mentioned as a critical aspect that should be considered when assessing the performance of clones over time.
- The opportunity to measure genotype by environment (GxE) interactions for important traits in the ICT could help us to understand the stability of traits better and thus might provide us with research direction with respect to climate change.
- It is suggested to map out how project clones and varieties that derived from them have been used in breeding programmes.

5.2.5. Analyses of on-station trials planted in the germplasm and in the productivity projects

- There is a need to continue data collection in the younger trials
- There is a need for further and more in-depth data analyses
- It was suggested to identify the pedigrees of all selected varieties
- Clone names should be standardised in the Final Project Publication (as far as possible in reference to ICGD)
- It was suggested to create a database with raw data to be analysed and USDA-Miami offered to host such a database
- Fingerprinting data already available as well as further fingerprinting is required to be able to compare data between sites

- It was suggested to create guidelines for standardised data gathering in cocoa breeding and on how to carry out base calculations
- Although the first CFC/ICCO/Bioversity project has published Working Procedures, it was noted that the way of calculation of cocoa yield varied between countries. Cumulated, yearly, potential and real yield should be identified correctly to be able to compare data between sites.
- It was suggested to study the variation in yield over years within sites, and also between sites, with local weather data and soil types
- More information should be available on how to design variety trials comparing clones with seedlings, aiming at avoiding inter-plot interactions
- There is a need for further funding of the younger trials established with support of the project. A focussed approach is required (prioritizing trials). Governmental funding is to be pursued as well as associations with ongoing projects, aiming at establishing sustainable funding. Funding may be easier for activities near to the farmers and with farmers' involvement.

5.2.6. Germplasm enhancement and distribution

- Sources of resistance have been identified for Black Pod and Witches´ Broom, using early screening tests and these are being used in pre-breeding and breeding programmes.
- Most of the genes/parents are at international gene banks, available for countries that are interested.
- Several new sources of resistance against *M. roreri* were recently identified.
- Some of this material is being used and distributed in Central America for field evaluation and farmers use.
- More work is required to develop early test against frosty pod rot;
- Constrains to conduct research have been identified and should be taken into account for new plans.
- There are aspects of the host-pathogen-environment relationship that seems to be important to understand better, in order to clarify variations observed between field evaluations and artificial inoculation tests and to standardise early screening tests.
- Research questions have been formulated that may lead the way to continue or start new trials.
- The International Quarantine Centre at Reading (IQCR) has a well established procedure for transfer of material and for virus indexing which should be maintained and used to minimize this threat.
- PCR methods should be used to improve virus detection at IQCR.
- Somatic embryogenesis as a way to transfer germplasm should be evaluated.
- IPR status of germplasm exchanged should be clarified for future projects.

5.2.7. Resistance studies

Methodologies to assess witches' broom (WB) resistance

- Comparisons between the two methods used in Brazil to access resistance to WB (spray method and agar droplet method) indicated that both methods are efficient but because of many variations a more practical method need to be developed, although the spray method seems to be easier to use.

- The diameter of the broom base to assess resistance to WB is used in Trinidad and Venezuela, but not in Ecuador and Brazil because of the variation in symptoms expression between these countries.
- Need to standardize screening methods so as to obtain a faster method that can be used with confidence for evaluation of resistance to WB (laboratory test, seedlings test, field observation).

Mirid antixenosis, tolerance and resistance

- Antixenosis was correlated with cumulated damage caused by mirids in the field
- Tolerance to mirids might be explained by the tolerance to the *Lasiodiplodia theobromae* fungus

Existence of several types (at least 3) of the clone Pa150

- There is a need to focus further research on this issue (comparison of all the types of Pa150).

Promising clones for resistance

- The clone IMC47 seems to show combined resistance to black pod, witches' broom and *Ceratocystis*. Futher resistance studies need to be focused on this clone and on other promising clones (*e.g.* French Guiana populations).

Use of molecular markers for resistance studies

- In Brazil, molecular markers are very important for the breeding programme.
- In Nigeria and Cameroun, molecular markers appear to show associations with resistance to black pod disease.

5.2.8. Perspectives from industry point of view

- As main issues for sustainable cocoa growing were identified: pests and diseases, planting materials, and soil fertility.
- As quality criteria were identified bean size and uniformity, fat content, flavour and other organoleptic quality traits.
- The empowerment of farmers is one important issue in addressing the production constraints.
- Distribution of planting materials is a new initiative with cocoa industry involvement (Nestlé and Mars.Inc in Côte d'Ivoire).
- In summary: more cocoa is needed, closer links with farmers are required, deterioration of cocoa quality is to be avoided through specifications and traceability, building capacity on how to supply cocoa farmers with improved planting materials, and sector capacity building.
- Industry priorities with regard to environmental services of cocoa are pesticide rationalisation and cultural control of diseases and pests.
- The aim of industry is that cocoa should be a profitable crop, avoiding the move of farmers into other crops.
- Dark chocolates could be the way forward to increase consumption, but yet with reduced impact (1-2% of world market), as well as chocolates with increased health benefits (with increased anti-oxidants)
- The Cocoa of Excellence project was mentioned as an initiative promoting of superior cocoa origins. Questions to be answered are sustainability of this initiative as well as industry support for it.
- Among the benefits, the distribution of selected materials should be given due attention. It was argued however, that distribution of selected materials should not be done by breeders but by specialised institutions.

- Research agenda setting was identified as an additional benefit of the project, as well as mirid resistance studies in West Africa and the setting up of the Asian Cocoa Breeders' Group.
- Needs for continued activities were discussed briefly. Setting up of a new clone trial would need to consider use of well selected clones.
- The rationale for setting up new projects should be identified.

ANNEX 1. SUMMARY OF ACHIEVEMENTS AS COMPARED TO THE FIVE-YEAR WORK PLAN

Project Output	Project Activity	Planned Activities (5-year work plan)	Implementation during 5 year period	Degree of achievement
Component 1. Selection and validation of promising trees on-farm through a participatory approach				
1.1	***Survey on farmers' use and knowledge of planting materials***			
	1.1.1 Farm surveys (Brazil, Cameroon, Côte d'Ivoire, Ecuador, Ghana, Malaysia, Nigeria, Trinidad, Venezuela)	Farm surveys (in total 2,000 farms planned to be visited)	***Africa:*** Planned surveys finalised including visits to 2300 farms. Complementary interviews with farmers were carried out in Cameroon (400 as part of a PhD study), Ghana (1500) and Côte d'Ivoire (1000).	More than planned.
			Americas: Surveys including visits to 200 farms were mostly finalised already in Year 2 and in Year 3 in Brazil (Amazon region)	As planned
			***Asia**:* In addition to earlier surveys including 85 farms, in Malaysia 12 promising trees for CPB tolerance were identified in farmers' fields.	As planned
	1.1.2. Identification, description and collection of promising trees (countries as above)	Description and collecting of 2,000 farm selections	***Africa:*** Collecting of 1600 promising trees finalised before Year 3. Publication of farm survey results has been done mainly in the Proceedings of the Fifth INGENIC Workshop (2009).	As planned
			Americas: In total, 350 promising trees were selected and collected. In Brazil, six new selections with witches' broom resistance were made in the Amazon. In Ecuador, the farm survey in Esmeraldas generated so much interest that new collections have been carried out. Publication of farm survey results (Trinidad, Ecuador) was carried out in the INGENIC workshop proceedings.	More than planned
			Asia: In Malaysia 74 promising trees for yield and CPB tolerance were collected. No activities were foreseen in PNG.	As planned

1.2	***Distribution to farmers and validation of promising planting materials on-farm***			
	1.2.1 Establishment of on-farm trials (Brazil, Cameroon, Côte d'Ivoire, Ecuador, Ghana, Malaysia, Nigeria, PNG, Trinidad, Venezuela)	A total of 200 on-farm trial plots were planned. Activities varied between sites according to work plans and prior activities.	***Africa:*** A total of 206 plots have been established: 36 in Côte d'Ivoire, 42 in Ghana, 19 in Nigeria and 109 in Cameroon. Due to high mortality during the severe dry season of 2006/07 and to farmers' neglect, the number of active plots has been reduced to 27, 0, 9 and 74, respectively, totalling 110 plots that are still maintained and observed.	As planned
			Americas: A total of 38 trial plots were included in this activity: 15 in Brazil (mainly already established multi-location trial plots), 5 in Ecuador, 15 in Venezuela and 3 in Trinidad. Due to farmers' neglect, the number of active plots in Venezuela decreased to 10.	As planned
			Asia: Total number of plots effectively established is 14, with 8 plots in Malaysia and 6 plots in PNG. Due to lack of funding, the number of active plots in Malaysia decreased to 2.	As planned
	1.2.2 Evaluation and selection of planting materials on-farm	Activities planned vary according to work plans and prior activities.	***Africa:*** Observations on mortality and vigour were initiated in plots established in 2005-2008. CRIG and CNRA selections appear more vigorous than local farm selections.	As planned
			Americas: Evaluations of on-farm trial plots were initiated in Venezuela and Ecuador**.** In Brazil, two large on-farm trials established between 2001 and 2003 have been concluded and a simplified observation system has been put in place with 28 farms.	As planned
			Asia: In West New Britain (PNG), the already established on-farm trail plots before the start of the project have yielded valuable new selections. Yield observations have resumed after the CPB eradication campaign and compatibility was assessed on 60 clones. In Malaysia, early observations showed that some farm selections yielded as well as the local control clone PBC123.	As planned
	1.2.3 Dissemination to neighbouring farms	Planned for by the end of the project	High demand for improved varieties by neighbouring farmers has been met where possible. Dissemination of any new varieties to be identified in the on-farm trials will happen only after these trials have provided full results.	Activity below planning level, as on-farm trials not yet fully explored.

1.3	***Establishment and evaluation of farmers' selections on-station***			
	1.3.1 Multiplication of farm selections and planting on-station in Farm Selection Observation Plots (FSOP's)	Establishment of on-station FSOP's	***Africa:*** In Years 2 and 3, 1153 selections were established in FSOPs on 5.5 ha. An FSOP established in Côte d'Ivoire in 2006 had to be replanted in 2007 due to soil problems (1.7 ha).	As planned
			Americas: A total of 250 farm selections were planted in FSOP's. INIAP introduced a total of 122 farm selections to be planted in a collection on-station. In Brazil, four FSOP with Amazon farm selections were planted. UNAS established 48 more farm-selections in the nursery (totalling 97 selections).	As planned
			Asia: Three FSOP's were established in Malaysia with 62 farm selections and 3 control clones. No FSOP's were planned for PNG.	As planned
	1.3.2 Preliminary nursery and field evaluation of farmers' selections	Early screening for black pod resistance, where applicable.	***Africa:*** Ppr resistance evaluations have been carried out in Côte d'Ivoire, Nigeria, Ghana and Cameroon. Several accessions were as resistant as the resistant control clones showing potential of farm selections. Filed observations carried out in Ghana and Côte d'Ivoire recorded higher mortality rates and less vigour for farm accessions compared to breeders' selections.	As planned
		Field evaluation in established FSOP's	***Americas:*** Field observations on FSOPs established before 2004 have been carried out in Brazil (5 ha) and in Venezuela (1 ha).	As planned
			Asia: Evaluation in PNG of advanced Trinitario x Amazon crosses indicated several crosses with 10-50% higher yield than the control varieties. An advanced Trinitario clone trial that suffered severely from insect attack and CPB eradication activities was evaluated for pod wall hardness, showing large variation. Field evaluations of FSOP in Malaysia were initiated.	Advanced (PNG) and as planned (Malaysia).
	1.3.3 Characterisation of farm accessions	Molecular characterisation dependent on related projects or co-financing.	***Africa***: More than 2000 accessions were characterized by molecular markers, through co-financing arrangements. Publications on molecular data were carried out for the Cameroon, Côte d'Ivoire and Nigeria data.	More accessions characterised than planned. Publication behind in Ghana
			Americas: DNA analyses on 154 clones carried out in Venezuela. Additional DNA analyses of farm accessions could not be carried out in time (delayed co-financing arrangements).	Delayed

1.4	***Stakeholder participation and capacity building***			
	1.4.1. a National stakeholder meetings and annual field days	Organisation of national stakeholder meetings with farmers, extension workers, breeders, and private sector. Activity implemented according to local situation.	***Africa:*** Activity finished in Year 2 in Ghana and in Côte d'Ivoire. In Nigeria, a stakeholder meeting was held in August 2007.	Activity implemented less than planned
			Americas: A stakeholder meeting was held in Ecuador in November 2007. Further meetings with farmers were organised in Venezuela and Trinidad.	As planned
			Asia: No stakeholder workshops planned.	
	1.4.1. b Annual field days (on-farm trials)	Field days organised where on-farm trials are established	Annual field days and discussions with the participating farmers have taken place during the regular visits by the researchers of the collaborating institutions to the on-farm trials.	As planned
	1.4.2 Exchange of scientists for participatory selection activities	Participation in stakeholder meetings in neighbouring countries	Nigerian and Côte d'Ivoire scientists participated in the Ghana stakeholder workshop.	Activity less than planned. This activity was partly replaced by participation to the four Regional Project Meetings

Component 2. Validation and dissemination of promising varieties through enhanced international collaboration				
2.1	***Selection and validation of varieties in ongoing collaborative trials***			
	2.1.1 Evaluation and selection of varieties in trials established with support of the "Germplasm" Project	Maintenance and field observations of clone and hybrid trials (totalling 85 ha) carried out (mainly with counterpart funding).	***Africa:*** Observations on vigour, yield and disease resistance have been carried out at all sites. Ghana presents results on early yield of clones in the ICT and LCT, while analyses of population breeding trials appear to confirm the value of parental clones currently being multiplied to establish new seed gardens. Results obtained in Nigeria on the Hybrid Trial 1 have been used to establish new seed gardens to be able to disseminate the best hybrids (special local funding). Detailed results on mirid resistance and tolerance studies on ICT, LCT and hybrid trial progenies have been obtained. In Côte d'Ivoire, analyses of the Recurrent Selection trials resulted in new selections and new crosses to evaluate new hybrid output.	As planned
			Americas: Observations on vigour, yield and disease resistance carried out. Best clones of the ICT and LCT are reported by INIAP, INIA and MALMR. Several clones out yield the local control clones.	As planned
			Asia: Observations on vigour, yield and disease resistance have been carried out. IN PNG, outstanding new hybrids and clones were identified.	As planned
		Evaluation of quality traits in the ICT and LCT.	Fermented and dried bean samples were prepared during two years at seven sites. One hundred and ninety cocoa liquor samples were prepared by Guittard for sensory evaluation by three panels (CRIAD, CRU and Guittard). Data analyses show the large environmental influence on sensory traits. Cocoa pulp evaluations were carried out in Peru and Ecuador. Results suggest a weak relationship between pulp and cocoa liquor flavours (except possibly for floral flavour).	As planned (except for PN where the ICT has bee terminated)
		Evaluation of ICT clones for physiological traits.	The protocol prepared by the University of Reading has been applied at six sites. Results were analysed and presented at the Final Project Workshop.	As planned, but data no always good for in dept analyses.
		New selections made during project life span.	Numerous individual tree selections have been carried out in hybrid trials in Nigeria, Ghana, Côte d'Ivoire, Brazil, Ecuador, Venezuela and Peru. CEPLAC selected 19 interesting clones in on-farm trials.	As planned

2.1	2.1.2 New variety trials established on-station	Clone trial planned for Year 1 in PNG. Additional activity elsewhere.	***Africa:*** * New hybrid trials established at CNRA. * The on-farm trial set up is used in Cameroon to establish a large number of new multi-site hybrid trials using best parents available	These are additional activities in Africa.
			Americas: * CEPLAC established a new clone trial in the Amazon region. * UNAS created 7 new hybrids. * INIAP analyzed the first year data from the pruning trial, suggesting that heavy pruning is detrimental to yield and only slightly improves disease incidence. * INIAP also established three more clone trials in farmers' fields with Nacional clones	As planned
			Asia: * In PNG, a new hybrid trial was established using the best ICT clones as parents and also a new hybrid trial for multi-site testing of 16 of the best hybrids selected among Trinitario x Amazon crosses (see under 1.2). * In Malaysia, two new clone trials with 50 and 17 best individual tree selections were established.	As planned
	2.1.3 Regional Variety Trials (RVT)	Establishment of RVTs in the Americas and Africa	***Africa:*** * RVT mainly planted in Years 1 and 2 and completed in Year 3. In Côte d'Ivoire a new plot with 21 hybrids was planted.	As planned
			Americas: * RVT planted mainly before Year 3. * In Costa Rica, interesting results for monilia resistance is reported with selection of individual hybrids and trees.	As planned

2.2	**Germplasm enhancement for resistance to *Phytophthora* pod rot (Ppr), witches' broom (WB) and monilia**			
	2.2.1 Germplasm enhancement for Ppr resistance in Trinidad	Maintenance, field observations and detached pod test on 1,000 genotypes selected in the Germplasm Project.	* Maintenance and field evaluation for disease incidence (3 ha) has been carried out. * Detached pod test applied to 766 trees, 68% of which confirmed to be R or MR. This compares to 35 % R or MR accessions in the base population. * Pod and bean traits evaluated on 762 trees. * Approximately 1000 seedlings of 24 second cycle crosses were tested with the leaf disc test; 41% proved to be resistant.	As planned. Some delay in Year 4 due to problems with sporulation of the *Phytophthora* isolate
	2.2.2 Evaluation and selection for witches' broom (WB) resistance in Trinidad	Evaluation of accessions in the ICG,T (with WCF co-financing). Establishment of crosses between most resistant accessions and screening of individual seedling progenies.	* A total of 181 promising accessions were mass-screened for WB resistance by using spray inoculation and 42 accessions of these proved to be resistant by using the agar-droplet inoculation method. * Crosses between promising accessions made during the first 3 years yielded a total of 3974 seedlings that were inoculated with the agar droplet method between year 2 and year 5. A total of 1480 seedlings (37%) proved to be resistant or moderately resistant to WB. However, narrow sense heritability appeared to be relatively low (0.11-0.15) for the resistance traits observed with the year 1 seedlings. * A total of 176 seedlings from 28 crosses were selected for resistance to WB as well as to Ppr. * A total of 134 resistant seedlings selected in 28 crosses were planted in the field, together with 55 susceptible control seedlings and grafts of two control clones. * Field observations on WB attack were initiated in Year 5.	As planned. Some delay in Year 4 due to problems with sporulation of the *Phytophthora* isolate
	2.2.3 Selection for monilia and black pod resistance at CATIE, Costa Rica	Selection for resistance to monilia and black pod (CATIE activity mainly supported by WCF and USDA funding).	Approximately 400 genotypes (4895 pods inoculated from germplasm accessions or interesting trees) were tested for monilia resistance and 900 for Ppr resistance (8880 pods). Several accessions were identified with high levels of resistance to Ppr and fewer with relative good resistance to monilia. These findings open the scope for further breeding for monilia and Ppr resistance.	As planned

2.3	**Dissemination of selected germplasm through intermediate quarantine to user countries**			
	2.3.1 Quarantine and dissemination of selected germplasm	Reception of accessions at the intermediate quarantine facility at Reading (UK), virus-indexing, quarantine for 2 years and distribution to user countries.	*Reading University:* * The entire CFC/ICCO/Bioversity collection of 112 accessions was introduced into quarantine and nearly all accessions are now released from quarantine and available for distribution to interested user countries. * Twenty five seedlings from PNG with resistance to Ppr were maintained and made available for distribution. * A total of 222 budwood samples of the CFC/ICCO/Bioversity collection were distributed to 8 project partners. * A total of 115 budwood samples from PNG materials were distributed to 7 project partners. *CATIE:* * Catie made available selected germplasm (budwood or seeds) on a total of 76 occasions during the project lifespan to Reading quarantine and to Costa Rican or other Central American users.	As planned, with some delay due to initial failure of transfer of materials from Trinidad to Reading.
	2.3.2 Establishment of transferred germplasm in user countries	Nursery grafting and establishment of accessions from Reading.	Large quantities of budwood were introduced into Côte d'Ivoire, Ghana and Malaysia. This activity has been underdeveloped in most other countries.	Distribution of recommended clones from Reading is delayed by about one year.
	2.3.3 Development of pollen conservation methods	Improving methods for collecting, drying and conservation of cocoa pollen. Re-hydration tests.	Success is reported with pollinations using desiccated pollen kept for up to 12 months at -18°C. No differences were observed between genetic groups of pollen donors.	As planned

2.4	**Improvement, validation and use of rapid resistance screening methods**			
	2.4.1 Early screening tests for witches' broom (WB) and monilia	Starting of activities in 2006 planned in Brazil, Costa Rica, Ecuador, Venezuela and Trinidad.	* The agar-droplet method for WB resistance testing is routinely adopted by CRU. More consistent results were obtained with the broom base diameter (BBD) variable than with incubation period. A significant coefficient of correlation of 0.70 with field results (2006) was obtained for BBD observed on open pollinated seedlings. No infection success was obtained with inoculations of young fruits (cherelles). * CEPLAC has reported some positive results with inoculation of young fruits with WB spores, but this method need further improvement * Inoculation of vegetative tissues with monilia spores carried out in Peru and Costa Rica has been abandoned as results have been negative. * Germination of spores on leaves looks promising (results from INIAP) but not at CATIE	The complexity of the testing methods proposed made it impossible to carry out all experiments at all sites. .
	2.4.2 Early screening for resistance to cocoa mirids in Côte d'Ivoire, Ghana and Cameroon	a. Application and validation of mirid resistance and tolerance evaluation methods in Cameroon, Côte d'Ivoire and Ghana. CRIN decided to join this activity.	* Results were reported for antixenosis and tolerance of ICT, LCT or hybrid accessions in Côte d'Ivoire and Nigeria. Antixenosis appeared related with cumulative mirid damage in Côte d'Ivoire. * Field resistance evaluations provided interesting results in Côte d'Ivoire, Nigeria and Ghana. * Indirect evaluation of mirid tolerance by mechanical damage has been tested in Côte d'Ivoire and Nigeria, with inconclusive results.	As planned, with exception for Ghana. The complexity of working with mirids has often lead to inconclusive or non-repeatable results.
		b. Fungi associated with mirid damage isolated, identified and pathogenicity demonstrated.	* Isolation of mirid-damage associated pathogens suggests combined presence of other pathogens than *Lasiodiplodia* in Cameroon and combined action of *Fusarium* spp. and *Lasiodiplodia* in Nigeria. * Pathogenicity tests with *Lasiodiplodia* isolates are ongoing in Cameroon (IRAD) and France (CIRAD). Results have been inconclusive.	As planned. However, results showed to be rather inconclusive when using *Lasiodiplodia* pathogenicity studies.
	2.4.3 Validation and application of new resistance screening methods	Validation and routine application of existing screening methods in national breeding programmes.	* Active evaluation for disease resistance with validated methods (mainly for Ppr and monilia resistance) has been carried out at several sites. * Application of new methods has been limited, due to the inconsistent results obtained with these methods.	As planned

2.5	**Identification of project materials by DNA markers and development of marker assisted selection methods**			
	2.5.1 Verification of genetic identity of project materials	Identity studies of accessions in collections planned at USDA, Miami and at CRU, Trinidad. This activity is co-financed.	* At USDA, Miami, more than 250 leaf samples from ICT clone accessions were characterised with SSR markers. Some off-types were identified, that were eliminated from the analyses. * In Venezuela, identity of some 150 local accessions has been carried out.	As planned
	2.5.2 Dissemination of elite progenies for QTL analysis and selection	Five "elite" progenies to be established each in two countries: Côte d'Ivoire, Ghana, Brazil, Ecuador and Costa Rica.	* Three QTL progenies have been established and are being evaluated for phenotypic traits in Ecuador, Costa Rica, Côte d'Ivoire and Ghana. * Severe drought has reduced the QTL progeny in Ghana to 111 surviving trees and has also reduced the original number of 480 trees in Côte d'Ivoire.	Reduction of five to three progenies.
	2.5.3 Identification of QTLs	Phenotypic observations and molecular analyses of field populations (co-financed activity).	* Phenotypic observations are ongoing at all sites. * Molecular studies on the Almirante progeny are ongoing at the UESC university in Bahia and in the USDA laboratory in Miami. * No other molecular studies have yet been initiated.	Phenotypic and molecular studies could not be carried out.
2.6	**Exchange of scientists between sites and training**			
	2.6.1 Exchange of scientists	Planned according to identified training needs and opportunities.	* In total, three scientists profited from exchange visits to neighbouring countries. * The exchange of scientists was compensated for by the organisation of regular regional workshops (see 3.1.1.b)	Less than planned. This activity was replaced by the four regional project workshops.
	2.6.2 Operational support for formal training of scientists	Planned according to identified needs and opportunities.	* Bruno Efombagn (IRAD), Peter Aikpokpodion (CRIN) and Désiré Pokou (CNRA) have elaborated their PhD thesis (French scholarship), using results from the project. Stephen Opoku (Ghana) also used the data for obtaining a MSc degree. * The project has allowed for numerous undergraduate studies to be completed using project materials. This was especially the case in Ecuador, but also in Venezuela and Costa Rica.	As planned

Component 3. Exchange of information and dissemination of results outside the project				
3.1	***Organisation of project meetings, analyses of data and dissemination of results***			
	3.1.1 Project workshops and meetings	a. Project launching workshop.	a. The workshop was held in Reading University in March 2004. The presentations were disseminated on a CD-Rom to all project partners	a. As planned
		b. Regional African Project Meetings (Year 2 and Year 4). Co-financed by USDA.	b. The Year 2 workshop was co-organised by IRAD (Cameroon) and Bioversity. It was held in Yaoundé in November 2005. The Year 4 workshop has been prepared jointly by Bioversity and CNRA and was held in Abidjan from 18 to 22 February 2008. Conclusions and presentations of these workshops were distributed on CD-Rom to all project partners.	b. Additional activity made possible through increased co-financing from USDA
		c. Regional American Project Meetings (Year 2 and Year 4). Partially co-financed by USDA.	c. The first regional American Project workshop was held in Miranda, Venezuela, in February 2006. The regional American project workshop was organised by INIAP and Bioversity in Guayaquil from 20 to 25 August 2007. The theme of the workshop has been enlarged to include progress on cocoa breeding also in countries that are not participating in the project (Dom. Republic, Mexico and Colombia). Conclusions and presentations of these workshops were distributed on CD-Rom to all project partners.	c. Additional activity made possible through increased co-financing from USDA
		d. Elaboration of Project Working Procedures Manual (outcome of project workshops)	d. Project Working Procedures have been proposed and discussed at the four regional project meetings. These related mainly to disease and pest resistance testing methods. Because of the inconsistent results obtained with these procedures, it was decided not to elaborate a specific manual for the project working procedures..	d. Compilation of working procedures has been abandoned
	3.1.2 Data analyses and publications	a. Analyses of project data from collaborative trials.	a. Data analyses of common project activities have been carried out at CIRAD. These include the analyses of hybrid trials in Ecuador and Ghana, and the data on sensory evaluation of the clones in the ICT.	a. As planned, with delays due to the passing away of Didier Paulin (CIRAD collaborator)
		b. Project publications	b. A total of 86 articles were published that include results obtained partially through support of the project.	b. On schedule
	3.1.3 Databases	Introduction of data into the International Cocoa Germplasm Database (ICGD)	Data introduction into databases has not been carried out. This will be possible once all the date have been compiled in the Final Project progress reports.	Activity delayed until the end of the project.

Component 4. Project Coordination, Supervision and Management *(only BIOVERSITY activities are reported here)*				
4.1.	**Coordination, Supervision and Management**			
	4.1.1 Project Coordination (BIOVERSITY Coordination Unit)	a. Elaboration of annual Letters of Agreement (LOA) with collaborating institutions.	a. Annual letters of Agreement (LOAs) for Years 1 to 5 were signed by all collaborating institutions. These include the annual work plan and budgets.	a. As planned
		b. Annual Work Plans and Budgets.	b. The Work Plans and Budgets for Year 1-5 were received and verified for each of the collaborating institutions. Bioversity compiled and sent these to CFC and to ICCO before the end of the ongoing project year.	b. As planned
		c. Visits of the Project Coordinator to collaborating institutions (Years 1, 3 and 5).	c. The international Project Coordinator has visited most project partners during project Years 1, 3 and 5. Mr. Paulin (CIRAD scientist) visited Côte d'Ivoire and Cameroon in 2005as part of the additional support that CIRAD provided to the project coordination.	c. As planned, except for year 5 when no visits could be carried out to Malaysia, PNG, Nigeria and Ghana (due to health reasons).
		d. Administrative and financial coordination activities (BIOVERSITY Coordination Unit), including organisation of annual audits of the Project Account.	d1. CFC funds for implementation of project activities in Years 1-5 were made available based on the Annual Project Work Plans and Budgets and according to the LOA's for Years 1-5. d2. The Years 1-5 financial reports of all collaborating institutions for the respective reporting periods were requested and verified. d3. Bioversity presented financial claims to CFC at annual basis. d4. Bioversity also claimed for the USDA contribution to the costs of the Regional Project Workshops.	d. As planned

Component 4 (Continued). Project Coordination, Supervision and Management *(only BIOVERSITY activities are reported here)*				
4	4.1.2 Exchange of information within the project	Elaboration and distribution of travel and progress reports.	* Travel reports of the visits of the Coordinator and of Mr. Paulin to collaborating institutions were elaborated and distributed. * The six-monthly and annual progress reports were analysed by the Coordinator and used to elaborate the General Progress Reports for Years 1-5. The Individual Institute Progress Reports (compiled in the Appendix) were distributed together with the General Progress Reports..	As planned.
	4.1.3 Project management and supervision	Interaction with CFC and with ICCO on project arrangements and financing.	* The Project Coordinator interacted with CFC to obtain authorisation for compensations for increased operational costs and losses due to exchange rate fluctuations in the Year 2-5 project budgets. These concerned 7 project sites (IRAD, CRIN, CCI, INIAP, MCB, UNAS and CNRA). CFC has accepted the requested modifications in the use of the CFC funds. The additional funds were made available from the Project Contingencies. * The Project Coordinator organised a joint visit of Mr. Abubakar (ICCO) and of Mr. Cromme (CFC) and himself to Malaysia and to PNG as part of the mid-term evaluation of the project.	As planned

ANNEX 2. PUBLICATIONS OF PROJECT RESULTS

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Okeniyi, M. O., S. O. Afolami, A. O. Fademi and P. Aikpokpodion, 2009. Evaluation of cacao (*Theobroma cacao* L.) clones for resistance to root-knot nematode *Meloidogyne incognita* (Kofoid & White) Chitwood. *Journal of Applied Biosciences* 17:913-921

IRAD, Cameroon

M.I.B Efombagn, O. Sounigo, A.B. Eskes, J.C. Motamayor, M.J. Manzanares-Dauleux, R. Schnell and S. Nyasse (2009) Parentage analysis and outcrossing patterns in cacao (*Theobroma cacao* L.) farms in Cameroon. *Heredity* Vol. 103 (1), 46-53.

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CNRA, Côte d'Ivoire

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ANNEX 3. FULL NAMES AND ACRONYMS OF PROJECT PARTNERS

National agricultural research institutions (NARS)

- Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica
- Cocoa Research Institute of Nigeria (CRIN), Nigeria
- Cocoa Research Institute of Ghana (CRIG), Ghana
- Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC), Brazil
- Instituto Nacional de Investigaciones Agrícolas (INIA), Venezuela
- Centre National de Recherche Agronomique (CNRA), Côte d'ivoire
- Instituto Nacional de Investigaciones Agropecuarias (INIAP), Ecuador
- Institut de Recherches Agronomiques pour le Développement (IRAD), Cameroon
- Malaysian Cocoa Board (MCB), Malaysia
- Ministry of Agriculture, Land and Marine Resources (MALMR), Trinidad and Tobago
- PNG Cocoa & Coconut Institute (CCI), Papua New Guinea
- Universidad Nacional de la Selva (UNAS), Peru

International agriculture research institutes (IARI)

- Centre de Coopération Internationale en Recherches Agronomiques pour le Développement - Département des Systèmes Biologiques (Cirad-Bios), France
- Cocoa Research Unit (CRU), Trinidad and Tobago
- United States Department of Agriculture (USDA), USA
- University of Reading, Reading, UK

Co-financing organisations

- Cocoa Research Association (CRA), UK (formerly Biscuit, Cake, Chocolate and Confectionery Association or BCCCA)
- CIRAD, France
- Guittard Chocolate Company, USA
- Mars Inc. Company, UK and USA
- USDA, USA
- World Cocoa Foundation (WCF), USA

Supervisory Body

- International Cocoa Organization (ICCO), London, UK

Project Executing Agency

- Bioversity International (or Bioversity), Italy, through the Project Coordination Unit which is part of the Commodities for Livelihoods Programme (CfL), Montpellier.

Main Financing Institution

- Common Fund for Commodities (CFC), Postbus 74656, 1070 BR Amsterdam
  Amsterdam, The Netherlands