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BCCCA

THE BISCUIT, CAKE, CHOCOLATE & CONFECTIONERY ALLIANCE

To: Cocoa Research Sub-Committee

From: Michelle End
Date: 7th March 1997

CFC Cocoa Germplasm Utilisation and Conservation Project

I have enclosed a copy of the final draft of the Project Proposal as submitted and approved by CFC. Mr. Lass has asked me to remind Committee members that the contents and figures included in Table 2.1 for co-financing initiatives are "indicative only" and that BCCCA is not necessarily committed to additional expenditure as indicated. There will be an opportunity to discuss this at the next Sub-Committee meeting on 20th March.

37-41 BEDFORD ROW LONDON WC1R 4JH
TELEPHONE: 0171-404 9111
FAX: 0171-404 9110 email: bccca@cix.compulink.co.uk

PROJECT PROPOSAL

COCOA GERMPLASM UTILIZATION AND CONSERVATION: A GLOBAL APPROACH

Prepared by

International Plant Genetic Resources Institute (IPGRI)
Via delle Sette Chiese 142
00145 Rome. Italy
Tel: (+39-6) 518921; Fax: (+39-6) 5750309

In close co-operation with institutes in cocoa producing countries in South America, Africa and Asia, and with ACRI, BCCCA, CAOBISCO, CIRAD-CP, CPA and CRU (see page 42 for explanation of abbreviations)

July, 1996 — FINAL

The International Cocoa Organization (ICCO) as the designated International Commodity Body on Cocoa (ICB) hereby submits the following project proposal with its recommendations for financing through the Second Account of the Common Fund. The proposal was approved by the International Cocoa Council in September 1995.

Project Title: Cocoa germplasm utilization and conservation - a global approach

Duration: 60 months

Location:

Cocoa Research Institute of Nigeria (CRIN)
Cocoa Research Institute (CRI), Ghana
Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Brazil
Institut des Forets (IDEFOR) Departement Cafe-Cacao et autres Plantes Stimulantes (DCC), Ivory Coast
Instituto Nacional de Investigaciones Agropecuarias (INIAP), Ecuador
Institut de Recherches Agronomiques pour le Developpement (IRAD), Cameroon
Malaysian Cocoa Board, Malaysia
Ministry of Agriculture, Land and Marine Resources, Trinidad
PNG Cocoa & Coconut Research Institute, Papua New Guinea
Fundacion Nacional de Investigaciones AgroPecuarias, Venezuela

Project summary

The project aims at a more sustainable production of cocoa at lower costs by making optimal use of cocoa germplasm. An internationally co-ordinated effort is proposed in screening, selecting and breeding of improved cocoa genotypes. Selection for resistance to some of the major diseases and pests, which are important destabilizing factors in many producing countries, will be a priority objective. The project focuses at establishing functional links between germplasm conservation, evaluation and selection activities in a joint effort to increase the genetic potential of cocoa germplasm. It is believed that this initiative is an outstanding opportunity to significantly improve the quality of planting material available to cocoa growers, especially to cocoa growing smallholders.

During the five years covering the period of this project proposal, the following activities will be carried out:

- Multilocational clone and hybrid trials, containing introduced and locally available genotypes, will be established at about 10 different sites with a view to selecting superior genotypes, assessing their breeding value as well as their genetic stability for economically important traits;
- Population breeding activities will be initiated at five strategic sites, aiming at sustainable improvement of cocoa;

- Internationally conserved germplasm will be characterized and evaluated to strengthen germplasm enhancement programmes;

- Selected genotypes from the international collections will be distributed to interested user countries.

The project will require efficient co-ordination, training and scientific/technical backstopping. Two workshops are planned, one at the beginning of the project to decide on screening, evaluation and other procedures, and one at the end to analyze and disseminate results.

The proposed conservation and characterization activities will be supported through counterpart contributions and co-financing, especially by associations of cocoa processors and chocolate manufacturers as well as by CIRAD. Selection, breeding and project co-ordination depends largely on CFC financing, on counterpart contributions (national institutions) and, to a lesser extent, on co-financing. To achieve success the project requires excellent liaison between all participants.

In view of the long-term nature of cocoa breeding it is anticipated that a further phase will be needed to consolidate the achievements of the present project..

Total cost of project: (1 SDR=1.45US$)	US$ 10,167,000 SDR 7,011,724
Financing sought from the Common Fund:	US$ 2,942,000 SDR 2,028,966
Co-financing:	US$ 2,300,000 SDR 1,586,207
Counterpart contributions:	US$ 4,925,000 SDR 3,396,552
Project Executing Agency:	International Plant Genetic Resources Institute (IPGRI), Rome, Italy
Supervisory Body:	International Cocoa Organization (ICCO), London, UK
Estimated starting date:	1 January 1997
Submission date:	July 1996

TABLE OF CONTENTS

INTRODUCTION

The first draft proposal was drawn up as a result of an informal meeting held in Kuala Lumpur in October 1994, with representatives from the following institutions: the Cocoa Producers Alliance (CPA), representing cocoa producing countries, CATIE, CRU, CIRAD, IPGRI and cocoa manufacturers organizations (ACRI, BCCCA and CAOBISCO). During this meeting a consensus was reached that IPGRI would officially co-ordinate the preparation and presentation of the proposal. The Part I proposal was submitted to ICCO in December 1994 with a copy for information to the CFC Secretariat. Comments were received from the latter and introduced into a revised and more extended Part I proposal, that was analyzed by the ICCO Expert Working Group on Cocoa Research and by the ICCO Council in June and September 1995, respectively. ICCO officially forwarded the proposal to the Consultative Committee of the CFC in November 1995 and formal comments were received in February 1996.

In close collaboration with interested parties, IPGRI began to prepare Part II in November 1995. Individual cocoa producing countries were contacted to assess their interest in greater detail. Answers received from the 18 countries contacted were very positive as to the objectives, value and approach of the project. These countries expressed interest in participating in one or more project activities (see Appendix VIII summary of replies). The interested parties were contacted once more in April 1996 to plan further details of the project, including the anticipated role of the participating partners. Based on these replies (Appendix VIII summary of replies) and incorporating the comments made by the Consultative Committee of the CFC, Part II of the project has been compiled.

During the course of finalizing Part II the project was presented to the International Workshop on the Utilization of the Genetic Resources of the International Cocoa Genebank, June 1996 in Trinidad and the delegates formulated the following recommendation:

> *"The IPGRI Project Proposal for the UN Common Fund for Commodities entitled "Cocoa Germplasm Utilization and Conservation - A Global Approach" was presented and discussed both in plenary session and on a bilateral basis. In the light of the pressing need for improved planting material for smallholder cacao cultivation in many participating countries, this initiative was welcomed and commended to ICCO. It was hoped that CFC funding would be agreed and that the project would be implemented at an early date."*

In accordance with one of the comments received from CFC in February 1996, both conservation and characterization activities will now be exclusively supported by co-financing institutions. However the evaluation activities in the project, being intimately related to breeding, are proposed to be supported by CFC funding. Consequently, CFC funding, together with co-financing, is proposed for the screening, selection and breeding activities as well as for the co-ordination of the project.

In order to address the concern expressed by the Common Fund for Commodities over the possible overlap of this project with the one on Witches' Broom sponsored by CEPLAC (Brazil), and also submitted to the CFC by the International Cocoa Organization, discussions were initiated with the Brazilian researchers involved in the preparation of the Witches' Broom Project. The two projects are dealing with complementary approaches to cocoa breeding which are of mutual benefit to each other. In view of the economic importance of witches' broom disease in Latin America and the threat of further spread, it seems justified to develop both strategies simultaneously. Exchange of information generated in the two projects and of selected germplasm, if of relevance to the other project, is suggested. The present Germplasm Utilization and Conservation Project will use clone selection and population breeding strategies in a large number of countries in Africa, America and Asia, aiming at increased international cooperation in the area of cocoa improvement while the Witches' Broom Project will be confined to Latin America and to one disease. Although one of the objectives of the Germplasm Project is to obtain disease resistance varieties, other locally important selection traits related to the qualitative and quantitative improvement of cocoa, are equally considered.

A. COMMODITY BACKGROUND AND STRATEGY

1. Cocoa Production and Consumption

Cocoa is a commodity produced in the developing countries of the tropics and consumed mostly in the middle and high income countries of the world's temperate zones. A number of cocoa-producing countries rely on cocoa exports for a significant proportion of the foreign exchange earnings they need to finance economic development projects and to service external debt obligations. In Ghana, for example, export earnings from cocoa, until recently, accounted on average for nearly two-thirds of its total foreign exchange earnings and in Côte d'Ivoire for about one-third.

From a level of 1.5 million tonnes in the 1983/84 cocoa year, world production of cocoa beans has increased to 2.3 million tonnes in 1994/95. This significant rise is almost entirely due to an increase in production area. Since 1990/91, however, world production declined from this peak, until the current 1995/96 season, for which world production is expected to reach a new record level. Nearly all producing countries grow cocoa on an extensive basis resulting in low average yields (400 kg of dry cocoa per ha or even less under some circumstances). The average global productivity has increased little over the last three decades. This contrasts with often dramatic advances in yields of other tropical or temperate crops and thus in the raw materials often used to manufacture other snack foods which are competitive with cocoa. Gains in global productivity of cocoa are now essential for the commodity; as pressure on available land increases, the need for higher yielding pest/disease resistant cocoa varieties becomes ever more urgent.

World cocoa consumption over the last ten years had also increased steadily, but at a slower rate than production, rising from 1.7 million tonnes in 1983/84 to more than 2.5 million tonnes in 1994/95. ICCO data shows that the regional distribution of grindings witnessed significant changes in recent years. Western Europe increased its share of world grindings from 39% in 1988/89 to 46% in 1994/95. The share for Asia and Oceania rose from 9% to 13%, but Eastern Europe saw a dramatic drop in its share from 14% to 6%.

The shares of the Americas (28% in 1994/95) and Africa (10% in 1994/95) were little changed as was the share of cocoa producing countries as a group (29%).

Prices of cocoa have fluctuated strongly as a consequence of discrepancies between supply and demand. Between 1985 and 1990 a 50% drop occurred in international cocoa prices, from about 2,000 to 1,000 US$ per ton. Presently prices are still relatively low, about 1,400 US$. The prolonged period of low prices has affected private as well as public cocoa research and development projects, together with associated areas of cocoa production. The continuity of many cocoa breeding and germplasm conservation programmes is acutely threatened. Recently, some important cocoa breeding programmes in South-East Asia, funded by the private sector, have been abandoned.

2. *ICCO Strategy*

A major objective of international co-operation between cocoa producers on 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 (ICCO, 1994)[1]. 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, the ability to control changes in production capacity within a reasonable time, measures to increase productivity and facilitate the orderly transfer of resources into and out of cocoa; the direct exposure of production decisions to market forces; the promotion of transparency in marketing arrangements; the conservation and improvement of cocoa genetic materials and the defence of the competitiveness of cocoa *vis à vis* other agricultural crops, through quality improvements 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 it is successful, it should contribute significantly to an avoidance of the boom-bust cycle for cocoa and enhance the prospects for a prosperous world cocoa economy.

B. PROJECT RELATED BACKGROUND

1. *Production Factors and Constraints*

Most cocoa growing areas have been developed on forest land previously used for timber extraction, with some forest trees kept to provide shade or using leguminous shade trees. Growing in the full sunlight, a rather recent development, ensures higher yields but calls for higher fertilizer inputs and more regular phytosanitary treatments due to increased

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[1] For endnote details see Chapter R.

insect damage. However, incidence of diseases is generally higher for shaded than unshaded cocoa. About 86% of world cocoa production is realized by smallholders[2] especially so in Africa (Lass and Varangis, in press)[3] Use of fertilizers is limited but that of insecticides and fungicides is more common due to the prevalence of cocoa insects and pests.

Average world-wide cocoa yields are about 400 kg/ha, varying between countries from 150 to about 800 kg/ha (ICCO, 1993)[4]. However, under experimental conditions and in occasional commercial fields, yields over 2.5 tonnes have been achieved with high level of input. The economic life span of a plantation is a maximum of 20 to 30 years, but this can be substantially shortened by destructive diseases and pests. Replacing old cocoa fields with new varieties is a continuous challenge for cocoa farmers, hence the importance of an effective and continuing supply of improved varieties to the growers. Generally, smallholders are unable to successfully select improved planting material and thus rely on national or international initiatives to have reliable access to new varieties.

The main production constraints of cocoa are diseases and pests. The most important diseases are black pod, witches' broom, vascular streak dieback (VSD), monilia and the cocoa swollen shoot virus (CSSV). Black pod (*Phytophthora spp.*) occurs world-wide, causing average yield losses of about 20%. The most destructive form of the disease, i.e. damage caused by the species *P. megakarya*, causes crop losses up to 70% in Central Africa (Cameroon, Nigeria, Togo). This species is presently spreading westwards in Ghana and threatening Côte d'Ivoire, the world's largest cocoa producing country.

Monilia and witches' broom, caused respectively by *Moniliophthora roreri* and *Crinipellis perniciosa*, are destructive diseases originating from the Andean countries and the Amazon basin in South America. Monilia spread to Panama, Costa Rica and Nicaragua during the last 10 years and can cause up to 95% pod losses. Witches' broom spread from the Amazon Region of Brazil to the State of Bahia, which is the main Brazilian cocoa growing area in 1989, being partly responsible for the 30% reduction in the total amount of cocoa produced in that State in recent years. Average yield losses in countries where this disease occurs can be estimated to be 20 to 40%.

VSD, caused by *Oncobasidium theobromae* is a relatively new disease that spread across most cocoa producing areas in South East Asia in the 1970's and 1980's. It kills susceptible young cocoa plants and debilitates old stands. CSSV, occurring in Nigeria, Togo and Ghana, causes the general degeneration of plantations. It is most serious in Ghana where some 200 million cocoa trees infected with the virus have been eliminated during the last 40 years in an attempt to control the disease. The above mentioned diseases are expected to continue their spread within the continents affected but might also invade other continents. For instance there seems no obvious reason why witches' broom should not also thrive in West Africa or South-East Asia from where it is currently absent.

The most common insect pests are sucking insects, particularly mirids and thrips. Mirids cause substantial damage in Africa and Asia whereas thrips are more common in South America. These insects can destroy cocoa plantations exposed to low or no shade conditions, necessitating frequent insecticide applications. In South-East Asia, cocoa pod borer (CPB) causes high crop losses - of up to 90% if no control measures are taken and is spreading within newly established cocoa growing areas in Indonesia (Sulawesi, Sumatra).

Chemical control of diseases or pests is not always possible (VSD, witches' broom, CSSV, CPB) and is sometimes very expensive as frequent spraying (CPB, black pod) is needed. In any event such applications should be minimized to reduce environmental pollution and health risks to farmers. Planting material with effective resistance to most of these diseases and to all pests is not yet available, although genetic variation for degrees of resistance is generally found.

It can be concluded that the extensive way of growing cocoa is directly related to the production structure, predominated by smallholders. Some donors and other international bodies still classify cocoa as a "plantation crop". In practice, cocoa has proved hard to cultivate on a large-holding basis, as illustrated by the uprooting of cocoa on estates in Malaysia during recent years (Lockwood *et al*, in press)[5]. With continuing predominance of small cocoa farmers, it is difficult to introduce technological changes that depend on increased financial inputs - especially in periods of low cocoa prices. The introduction and use of improved varieties is therefore one of the most cost-effective and environmentally friendly technological changes that can be proposed to overcome the major cocoa production constraints.

2. Current Cocoa Varieties and Genetic Improvement Strategies

About 40% of world cocoa is supplied by varieties selected at research stations. The majority of these are so-called hybrid varieties (mixtures of bi-parental crosses) which are reproduced in seed gardens, generally through hand pollination. Less than 5% of total cocoa production is provided by selected clonal varieties, propagated as rooted cuttings or as grafts. The rest is still produced by old varieties, like Criollo, by slightly improved populations (e.g. open pollinated Upper or Lower Amazon Forastero populations) or by unselected heterogeneous materials. Practically all cultivated varieties, selected or unselected, are very susceptible to diseases and pests of local importance.

Cocoa breeding started early this century mainly by clone selection in heterogeneous Trinitario populations, resulting in the identification of some well-yielding clonal varieties still in use today (e.g. Indonesia, Trinidad and Tobago). Cross progenies among selected Trinitario clones were generally less interesting. After the witches' broom disease appeared in Trinidad, expeditions were organized in the 1930's and early 1940's to search for resistant cocoa trees in Peru and Ecuador. The results of these expeditions were considered disappointing because only very few highly resistant trees could be identified. However, it was soon found that hybrid vigour was expressed in crosses between introduced Forastero clones from the Upper Amazon region and local clones. Such hybrid varieties were tested in many countries and generally provided better establishment capacity, vigour, precocity and yield potential compared to traditional local varieties. Subsequently, during the last four decades, cocoa breeding has largely depended on selection of crosses between genetically unrelated parental clones. These hybrid varieties have been widely distributed to growers, and today occupy about 35% of total cocoa acreage (Paulin and Eskes, 1995)[6]. The initial success of hybrid selection has meant that clone selection received little attention in most cocoa growing countries.

However, several shortcomings in **conventional hybrid cocoa breeding** have been identified during the last two decades. The most important problems are heterogeneity of hybrid varieties, composed of mixtures of different crosses, low resistance to diseases and pests and, sometimes, a rapid decline in production capacity with the ageing of plantations. These problems explain the reason why in some countries, farmers have abandoned the use of hybrids and returned to traditional more uniform varieties. Advances with traditional hybrid breeding methods are also expected to level off, as they heavily depend on identifying parental clones which combine all desirable traits, (high quality, yield and disease resistance) which are not yet available or not yet identified in existing germplasm collections (Kennedy *et al.*, 1987)[7].

Meanwhile, genetic studies in the cocoa crop have revealed additive inheritance of economically important traits, including disease resistance and yield. Significant correlation between the performance of parental clones and their offspring have been demonstrated (Lockwood and Pang, 1994)[8]. These findings open new avenues for cocoa breeding, as indicated in the Conclusions of the International Workshop on Cocoa Breeding Strategies, 1994 (Appendix VI), in particular:

- recognition of the validity of **evaluation of clones**, to be used directly as commercial varieties or as parents in further breeding;
- possibilities to improve parental genotypes for specific traits through recombination and selection in crosses (hereafter called **germplasm enhancement**);
- implementation of **population breeding** strategies, through recurrent selection procedures, aiming at long term improvement for all economically important traits.

In some countries, such as in Côte d'Ivoire and Malaysia, implementation of population breeding strategies has begun or is being considered (Paulin and Eskes, 1995)[6].

The evaluation, selection and breeding activities proposed in the present project, i.e. multi-locational clonal and progeny trials, germplasm enhancement and initiation of population breeding programmes, are fully in line with these recent developments.

In recent years, **new technologies** have evolved which may make significant contributions to improved understanding of the crop and, eventually, to the creation of improved varieties. The advances of **DNA-marker technology** has two important applications. First, it increases our knowledge of the genetic diversity of cocoa germplasm and, thus, facilitates the application of better oriented breeding strategies. Second, the recent establishment of a genetic linkage map using these markers makes it possible to apply "marker assisted selection", once significant correlation between DNA markers and selection traits have been identified (Lanaud *et al.*, 1995)[9]. This would allow for increased selection efficiency in progenies in which enough polymorphism for DNA markers is present. Co-operation between countries is useful to further develop this technology, making it more cost effective and more widely applicable. Advances in **genetic transformation** potentially allow for use of "foreign DNA" in tackling problems like resistance to cocoa swollen shoot virus (CSSV) and CPB. However, the relatively limited progress in cocoa micropropagation, regeneration and transformation techniques makes it very unlikely that this method will be available to overcome these production constraints within the foreseeable future.

Important advances have been made in recent years in developing more **reliable early screening tests** for resistance to diseases and pests, especially for the black pod and witches' broom diseases. For these diseases, non-destructive nursery or laboratory screening tests, using inoculation of young plants or leaves, have provided good results, for example in Côte d'Ivoire and Trinidad (MSc thesis of M. Tahi and PhD thesis of D. Iwaro, respectively). At the same time, increased knowledge has been obtained on the magnitude of the genetic variability available for resistance to many diseases in cocoa collections and in breeding fields. The nature of this resistance appears to be quantitative with additive inheritance predominating.

These findings suggest that disease resistance can be accumulated in crosses between less susceptible genotypes. Therefore, the application of adequate "classical" breeding methods, such as those proposed in the present project, would offer good opportunities for obtaining effective and sustainable progress in this area of applied research.

Many cocoa producing countries have been unable to maintain effective long-term breeding activities because of their limited financial resources, especially during the recent period of low cocoa prices. The continuity of several breeding programmes is endangered and a few have recently been abandoned, as is the case in Malaysia, where most of the cocoa breeding programmes are funded by the private sector. In addition, many breeders lack training and operate under isolated conditions, thus **international co-operation** in cocoa breeding is urgently needed. This is the main reason why in 1993 the International Group for the Genetic Improvement of Cocoa (INGENIC) was created. This Group, that operates with ad-hoc funding, publishes a newsletter and organized its first Workshop on Cocoa Breeding Strategies in 1994; a second INGENIC Workshop on varietal improvement for disease resistance is planned in Brazil in November 1996. INGENIC has been closely consulted during the development of this proposal.

3. *The Cocoa Genetic Resource Base*

Any cocoa breeding programme depends on the **availability of genetic diversity**. Such diversity can either be obtained from nature (usually "wild" genotypes), from farmers' fields (traditional local varieties or diversity present in more recently distributed varieties) or in research institutes where crosses between different genotypes lead to new combinations. Cocoa breeders have been creating working collections for over 60 years. More recently, efforts were undertaken to systematically establish germplasm collections with a more varied content in order to avoid the continuing loss of genetic diversity caused by deforestation, replacement of cocoa by other crops, introduction of new varieties, etc. It is estimated that the collections world-wide currently contain about 7,000 original accessions. There is a threat of loss of diversity in germplasm collections, not only due to natural calamities (fire, diseases), but also due to irregular funding.

Cocoa originated in South America and developed its genetic diversity over thousands of years in that continent. Domestication is reported to have taken place in Central America, by the Amerindians. Consequently, the existing international germplasm collections at CRU have been established in that part of the world. These collections containing approximately 3,000 and 800 accessions, respectively, have been officially recognized by the International Board for Plant Genetic Resources (IBPGR - now the International Plant Genetic Resources Institute - IPGRI) as international base collections. In addition, important national collections exist in the countries where cocoa naturally occurs or where it has been cultivated for a long time, including Brazil, Ecuador, Venezuela, Colombia and Mexico. Since the boom of cocoa as a new crop in West Africa and South-East Asia, breeding collections have been built up in these countries, including local selections and introduced germplasm from Latin America.

Transfer of germplasm from international germplasm centres to user countries is done through **intermediate quarantine centres** in Europe (Reading University, UK and CIRAD, Montpellier, France), where the health of the material is observed for at least two years before it can be distributed (Frison and Feliu, 1986)[10]. These quarantine centres presently contain around 250 and 200 available genotypes, respectively. However, the demand for new germplasm by user countries in recent years has been relatively limited, because the breeding value of this material is generally unknown and because of the restricted absorptive capacity of many institutes due to a general decline in breeding activities related to shortage of funds over recent decades.

Since the late seventies, systematic efforts have been initiated by the cocoa genebanks to **characterize** the germplasm, mainly by observing taxonomic traits. Such data allow curators and breeders to identify and classify the material, thus facilitating communication between researchers. The Cocoa Research Unit (CRU) more recently began to systematically describe its large collection but, to date, only a relatively small part has been completed (Engels and Dyce, 1994)[11]. With the development of new biotechnological tools, especially DNA marker technology, the possibilities to assess genetic diversity have significantly increased. These new technologies also allow the start of "fingerprinting", making it possible to identify individual clones or genotypes. Recently, the use of RAPD markers has been initiated at CRU and has already given promising results. It is not impossible that DNA marker technology will replace the traditional botanical methods for the characterization and study of genetic diversity of the collections. Few efforts have been undertaken so far to systematically carry out preliminary **evaluation** of germplasm collections for economic traits of direct interest to breeders such as yield, fat content, flavour and disease resistance. Such quantitative traits often vary according to the environment and, consequently, evaluation should preferably be done in user countries. However, centralized evaluation in the major germplasm collections for the more heritable economic traits, such as quality and disease resistance, would be more cost effective. Breeders around the world, who would have an interest in evaluated material with specific characteristics, could obtain such material from these collections, though more research is needed to verify the actual stability of such traits in different countries. The recent development of more efficient early screening tests for resistance to some major diseases, like black pod and witches' broom, permits more rapid evaluation of germplasm for these traits.

The available characterization and evaluation results of cocoa germplasm have been entered into existing **databases**, in particular the International Cocoa Germplasm Database, developed from 1990 onward at Reading University in the UK. The funding for this database, through the London Commodity Exchange, is secure for the foreseeable future (End *et al.*, 1994)[12]. It is intended that this data source will be used extensively in the course of this project.

It has been estimated that approximately 5% of the unique genotypes held in the international and national collections have been evaluated and **used** as parents to select new varieties, mainly in breeding programmes aiming at higher yield potential (Paulin and Eskes, 1995)[6]. The recent emphasis in cocoa breeding is to combine yield with other important traits, like quality and disease resistance. Most of the smaller national collections lack sufficient genetic variability for these traits and so **international collaboration** is essential to identify and disseminate interesting clones to be used in breeding programmes. The proposed project aims to relate characterization and evaluation of internationally available germplasm directly to the needs of breeders through a well co-ordinated co-operative effort between researchers, breeders and curators, both those working in international collections, as well as in the user countries.

C. PROJECT JUSTIFICATION AND OBJECTIVES

1. Justification

Against the aforementioned background information the project can be justified as follows:

a) Cocoa is, and for a considerable time, expected to continue to be a predominantly extensively grown crop produced mostly by smallholders;

b) One of the most efficient ways to enhance sustainable cocoa production is through the creation and use of improved varieties. This technology is easily transferred to smallholders compared to other technologies that require higher inputs;

c) Currently grown cocoa varieties show low resistance to major diseases and pests;

d) Genetic progress to overcome major production constraints can be expected through adequate application of proven breeding techniques as well as by additional evaluation of germplasm;

e) Clone selection as well as population breeding strategies appear to be the most appropriate selection strategies to obtain rapid short term progress and sustainable long-term genetic progress, respectively;

f) Application of germplasm enhancement procedures (pre-breeding), aiming at improvement of specific traits in breeding populations, is complementary to local breeding efforts in overcoming some of the major cocoa production constraints, like losses due to diseases. Such a procedure would benefit from additional evaluation studies carried out on germplasm; and

g) International collaboration will be essential to conserve, characterize, select and improve cocoa germplasm in a co-ordinated manner, and to subsequently distribute it. Because of the existing geographic "division" between areas with cocoa genetic diversity, the cocoa producing areas and the processing/manufacturing countries, only a global approach will be meaningful.

2. *Objectives*

The **wider development objective** is 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 by making optimal use of available cocoa genetic resources.

The **intermediate project objective** is to make improved cocoa planting material available with good yield and quality capacity, with resistance to diseases and pests, and which is well adapted to local conditions.

The **immediate project objectives** are:

2.1 To strengthen national cocoa improvement programmes and increase international collaboration by carrying out co-operative evaluation, selection and breeding activities in a number of countries, with the following outputs:

- **multilocational clone trials**, aimed at selection of superior clonal varieties, distribution of interesting new cocoa clones and assessment of the genetic stability of economically important traits;
- **internationally co-ordinated hybrid trials**, aimed at selection of improved genotypes and to give increased knowledge on inheritance of traits;
- initiation and/or strengthening of **germplasm enhancement activities** (or pre-breeding) at international base collection sites, aimed at obtaining parental clones and populations with increased disease resistance to be distributed to user countries;
- initiation or reinforcement of **population breeding programmes** in five major cocoa producing countries, aiming at long-term improvement of economically important traits, including disease resistance.

2.2 To establish cost effective and efficient conservation, characterization and distribution efforts of available cocoa germplasm, with the following outputs:

- creation of more efficient **conservation, characterization and distribution programmes;**

- establishment of **functional links** between germplasm curators at national and international level and cocoa researchers;

- **identification and distribution of interesting clones** from international collections or quarantine centres to user countries.

2.3 To strengthen cocoa germplasm utilization and conservation activities through scientific/technical backstopping, information exchange and human capacity building, including:

- **scientific/technical backstopping and co-ordination** of project activities to ensure their concerted implementation, to obtain genuinely comparable results and to provide scientific support where necessary;

- processing of project results, **database entry, dissemination of information** through publications, workshops and technology transfer;

- formation of an informal **network** between the participating **scientists and institutions** with a supporting role provided by the Executing Agency to enhance **evaluation/breeding** activities in cocoa growing countries, to ensure complementarity and avoid duplication of effort.

D. BENEFICIARIES

The selection and creation of improved varieties will be of great benefit to the **cocoa growers** in many countries. This will be especially so for the smallholders, who rely almost entirely on the supply of improved planting material from outside. It is expected that this approach will lead to more sustainable systems of cocoa cultivation, to the use of less land for similar production levels of cocoa, to less losses because of diseases and pests and other biotic stresses. 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 proposed international approach to cocoa improvement should benefit **cocoa researchers**, especially breeders, through the distribution of relevant genotypes, through the provision of funds to execute evaluation and breeding activities, and through increased collaboration between cocoa producing countries as well as with international germplasm and quarantine centres leading to improved efficiency in the research processes. The co-operation between cocoa research institutes in the developing countries and in developed countries will facilitate the transfer of technology and allow human capacity building, especially in the producing countries. This improved collaboration is seen as a very important benefit of the project and by the formation of an active network is expected to be long-lasting.

Intensified and improved international contacts are expected to facilitate access to the conserved germplasm and thus to strengthen indirectly the operations of the **National**

and International Cocoa Genebanks. Furthermore, this 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.

In **conclusion**, as a result of this project, all cocoa producing countries will be able to incorporate broader genetic diversity into their improvement programmes and, thereby encourage more productive and environmentally-friendly cultivation. The consumers of the cocoa products will benefit through more stable access to products at affordable prices and better quality.

E. CONFORMITY WITH COMMON FUND POLICIES

The proposed project conforms with the following general policy objectives of the Second Account of the Fund in helping to achieve stable conditions in cocoa trade through work which is consistent with the United Nations aims in the fields of food security and protection of the environment. The project is in accordance with the type of work supported, as indicated in the Manual, with regard to improvement of genetic material, avoidance of production losses through increased resistance to diseases and pests and improving sustainable management of genetic resources. It is also consistent with the Fund's preference for supporting work which will improve the quality of life of smallholders, some of which largely depend on the crop for export earnings.

More specifically, the project will:

- contribute to long-term stable co-operation between countries which possess the genetic diversity, the countries where cocoa is being produced and the countries where cocoa is processed and marketed;

- contribute to the sustainable conservation of the genetic resource base for breeding programmes and keep these resources available to the breeding programmes world-wide;

- make a significant contribution to environmental protection by developing better adapted pest and/or disease resistant varieties and thus, provide the basis for a more sustainable production approach;

- especially benefit the small producers who are frequently disadvantaged by the high cost of chemical disease and pest control;

- benefit both producers and consumers through the availability of better quality cocoa, grown with lowered application of pesticides.

F. PROJECT OBJECTIVES, OUTPUTS AND ACTIVITIES

The project outputs and activities are presented according to the three **immediate project objectives** identified in Paragraph D.

Objective 1

To strengthen national cocoa improvement programmes and increase international collaboration by carrying out co-operative evaluation, selection and breeding activities in a number of countries.

Output 1.1: International clone trials established in 10 countries

This **output** will compare a common set of 25 potentially interesting cocoa clones, to be supplied by intermediate quarantine centres, with local clones under different agro-physiological conditions. The trial will be set up in 10 different countries. The 25 international clones will also be supplied to other interested countries for parallel investigations as well as to the international germplasm centre holding base collections (CRU). This approach permits distribution and selection of new clonal varieties as well as evaluation of the genetic stability of economically important traits that have never been assessed before on an international basis across a wide range of cocoa growing environments. It will permit to know whether information obtained at one place can be meaningfully applied at other places, which is basic to the structuring of regional or international collaboration in the area of cocoa germplasm evaluation and selection. Specific attention will be given to resistance to black pod and witches' broom diseases for which the execution of "ring tests" are proposed, applying standardized early screening methods.

Activity 1.1.1

Reception and multiplication of budwood at each site; 25 clones will be received from international quarantine centres and 20 interesting clones will be chosen locally. The clonal material will be prepared as plagiotropic hypocotyledonary grafts or buddings. A few standard clones and/or hybrid progenies will be added to the trial to represent locally recommended varieties.

Activity 1.1.2

In countries where clone selection is of major interest, as part of the above trial, an additional 100-150 interesting trees will be selected within well performing hybrid varieties. The selection criteria to be applied will be good yield, moderate vigour and good disease resistance of the hybrid varieties and desirable fruit and bean characters of the individual trees. These trees will also be cloned as plagiotropic grafts to be planted in field observation.

Activity 1.1.3

Preparation of land (± 2.5 ha) and planting of the clones, using a random block design, with 6 repetitions of 8-10 trees per plot, applying locally recommended plant husbandry practices. Where applicable, the additional 100-150 locally selected clones will be planted in observation plots with 2 repetitions of 5 trees per plot.

Activity 1.1.4

Evaluation of the clonal progenies for resistance to those local diseases for which early screening tests are available, using inoculation on nursery plants or plant tissues (leaves). A standardized "ring test" will be carried out to evaluate resistance to black pod and to witches' broom, at locations where these diseases occur. These tests will also be carried out at two places outside cocoa producing countries (Montpellier, France, and Imperial College, Silwood Park, Ascot, respectively, or another suitable institution in the UK), using a range of isolates of the pathogen from a variety of field sites. This will verify the repeatability of the test and the existence of possible interactions between host genotypes and pathogen isolates or species.

Activity 1.1.5

As far as possible, observations on agronomic traits (vigour at different stages of growth, yield, fruit and seed characters), physiological traits (flowering and fruiting periods, estimation of above-ground biomass), attack by diseases or pests, and quality traits (shell content, fat content, butter hardness, flavour) will be conducted using agreed standard procedures. It is planned to establish standardized evaluation procedures during the first six months of the project and to formally decide on them during the first workshop. Evaluation of some of these traits (yield, field disease incidence and quality) can only be completed in a possible second phase of the project.

Activity 1.1.6

Analysis of data and reporting. Where necessary, assistance in the analysis will be provided by the Project Co-ordinator. Data will be entered into the databases and shared with the other partners in the project.

Output 1.2: Internationally co-ordinated hybrid trials established in six cocoa producing countries

The approximately 40 hybrid progenies of this **output** are to be created by intercrossing locally selected superior clones, which are included in the multilocational clone trial (see Output 1.1). This permits selection of superior hybrid varieties, comparison of the value of the parental clones with their progenies and, at a later stage, selection of individual trees within these hybrids to be used in further breeding. The use of statistically valid crossing designs will permit genetic analysis of the results to advance knowledge on inheritance of traits.

Activity 1.2.1

Preparation of land (± 2.5 ha) and planting of hybrid trials according to a randomized block design with 16 trees per plot and 5 repetitions using locally recommended plant husbandry methods.

Activity 1.2.2

Manual pollination according to a factorial crossing scheme and preparation of a nursery with 40 hybrid families, including standard hybrid and/or clone varieties. The standard varieties should be the same as the control varieties included in the International Clone Trial (see Output 1.1), to be able to compare the results between the two trials.

Activity 1.2.3

Early evaluation of the progenies in the nursery for resistance to those local diseases for which early screening tests are available using agreed standardized methodology. A comparison of resistance of parental clones (see Activity 1.1.4) with that of progenies will be completed.

Activity 1.2.4

Realization of observations on agronomic, physiological and quality traits using agreed standard procedures, as described in Activity 1.1.5.

Activity 1.2.5

Analysis of data and reporting. For details see Activity 1.1.6.

Output 1.3: Initiation and/or strengthening of germplasm enhancement activities (or pre-breeding) at the international base cocoa collection site (CRU) aimed at obtaining parental clones and populations with increased resistance.

This **output** involves improvement of cocoa populations for specific traits that can be usefully evaluated at the two international base collection sites, especially resistance to witches' broom, monilia and black pod diseases, while keeping genetic variation for other traits constant. This approach is justified by the large genetic variation present in these collections and by the need to obtain parental clones and breeding populations with increased resistance to major diseases. The selection activities will build on knowledge and populations already existing at the two sites. They will include new evaluation/screening activities and creation of additional populations to achieve these objectives. Towards the end of the project, a start will be made to transport identified clones, or populations, to user countries, applying the accepted standard phytosanitary and quarantine measures.

Activity 1.3.1

Choice of parental material (populations) to be used in the germplasm enhancement programmes based on existing information regarding the value and genetic make-up of the available germplasm. Evaluation of genotypes will be carried out through field observations on a few easily observable traits (vigour, bean size) and through rapid screening tests for resistance (leaf or fruit inoculations).

possible by using already available information but in some cases the existing information will need to be completed by rapid evaluation/screening tests before an adequate choice of parental genotypes can be made.

Activity 1.4.2

Intercrossing of selected genotypes of each population identified in Activity 1.4.1. Establishment of nurseries containing seedling progenies. Completion of early screening tests on nursery materials for resistance to locally occurring diseases, if applicable, aiming at selection of improved families and/or individual seedlings.

Activity 1.4.3

Field establishment of improved populations created under Activity 1.4.2 for further selection (expected acreage varying between 3 to 5 ha per country). Exchange of potentially interesting seed progenies to interested countries that face similar production constraints, following the agreed Technical Guidelines on Safe Movement of Cocoa Germplasm (Frison and Feliu, 1986)[10].

Activity 1.4.4

Evaluation (or completion of evaluation) for economically important traits in other potentially interesting trees belonging to the populations identified under Activity 1.4.1, aiming at enlarging the genetic base of the populations and at clone selection. Information on genotypes should be exchanged with other interested countries so that it can also be used in their breeding programmes.

Activity 1.4.5

Multiplication of about 250 selected trees, belonging to one or more populations of local interest, as clones by plagiotropic budding or grafting. Field planting of these genotypes in observation plots, containing two replications per clone and five trees per plot. This trial should also include the clones used in the international clone trial (see Output 1.1) as well as commercial control varieties. The expected acreage for this activity is 2 to 3 hectares per site.

Activity 1.4.6

Analyses of results and reporting. For details see Activity 1.1.6.

Objective 2

To establish cost effective and efficient conservation, characterization and distribution efforts for available cocoa germplasm.

Output 2.1: Available germplasm conserved, characterized and preliminary evaluation completed

Activity 1.3.2

Realization of crosses among the most interesting parental genotypes belonging to the same populations. Preparation of nurseries with crossing materials.

Activity 1.3.3

Application of early screening tests on nursery materials (resistance to witches' broom and black pod disease) to select the most resistant individuals within each cross progeny.

Activity 1.3.4

Field planting of most resistant selected seedlings, including a few well known susceptible/resistant control clones. Early field observations on selection traits will be realized (vigour, early flowering, pod and seed characteristics, resistance to diseases if possible) and confirmation tests for resistance carried out where needed.

Activity 1.3.5

Analyses of results and reporting. For details see Activity 1.1.6.

Output 1.4: Initiation or re-enforcement of population breeding programmes in five major cocoa producing countries aiming at long-term improvement of economically important traits, including disease resistance

This **output** involves initiation or strengthening of population breeding programmes using clone as well as hybrid selection and aiming at locally important breeding objectives, including yield, quality and resistance to diseases and/or pests. The available knowledge about the breeding value of specific clones or populations will form the basis of this work. Populations to be improved, through recurrent selection procedures, will be chosen depending on the breeding objectives and on locally available breeding material. In countries where the final objective is to obtain clonal varieties, any locally well-performing clones may be considered as part of the base population if they represent enough genetic variability to ensure selection progress. In countries where hybrid varieties are the main breeding goal, the use of more than one base population will be considered, making it possible to apply reciprocal recurrent selection procedures and, thus, exploit possible hybrid vigour between these populations. It is proposed to exchange basic breeding material (parental genotypes or seed progenies) between countries which face similar production constraints, thus stimulating regional/international approaches to cocoa breeding.

Activity 1.4.1

At each of the selected sites one, or a few, populations will be identified which are considered of interest to be improved and which offer best perspectives to overcome production constraints of local or regional importance. In some countries such populations have already been identified. Between 30 and 60 potentially interesting parental genotypes will be chosen for each population. This would normally be supported by co-financing.

Activity 2.1.5

Identification of a "core collection", containing about 100 especially interesting clones from the international collections exhibiting desirable characteristics. The selection of these clones is based on the results of activities 2.1.2 and 2.1.3. A detailed description of the characteristics of these clones, including the preparation of photographs of fruits and leaves, will allow a more rapid identification. Subsequently, these clones will be sent to intermediate quarantine centres for later distribution.

Activity 2.1.6

Analyses of results and reporting. The results will be incorporated in the national and/or international cocoa germplasm databases and made widely available.

Output 2.2: Interesting genotypes distributed and/or introduced into intermediate quarantine.

This **output** aims at the distribution of interesting genotypes identified in the project to participating countries, following the internationally agreed Technical Guidelines for the Safe Movement of Cocoa Germplasm, published by FAO and IBPGR (now IPGRI). It is envisaged that the exchange of cocoa germplasm between the participating institutions will be without restrictions. Germplasm maintained at the international collections is internationally available on request to all *bona fide* users.

Activity 2.2.1

Multiplication and shipment of budwood of the 25 clones that will be included in the international clone trial (see Activity 1.1). These clones will be chosen, based on available information on the genetic origin and agronomic value among the 450 clones actually maintained in the international quarantine centres at CIRAD, Montpellier, and at the University of Reading, UK. All interested countries, including those not formally participating in the clone trial can receive these clones upon request.

Activity 2.2.2

Shipment of interesting genotypes identified in the project activities (1.3.1, 2.1.5) to one of the intermediate quarantine centres. Subsequent distribution of these genotypes to user countries upon request (see Activity 1.4.3). It should be noted that the standard intermediate quarantine procedure takes up to two years, depending on the respective national plant quarantine regulations. Efforts should be undertaken to study other possible efficient ways of exchange of germplasm, such as transport of seed and pollen.

This **output** aims at maximising the efficiency of management and maintenance procedures to existing national and international base collections. Through the improvement of the functional links between these collections and the national/international breeding activities, an improved utilization of the conserved germplasm can be expected. Better co-ordinated and intensified characterization and (preliminary) evaluation of the material in the collections will facilitate the selection of genotypes which are of actual or future interest to breeders as well as the formation of so-called core collections. Simultaneously, the curators of the collections will obtain a better understanding of the presence (or absence) of genetic diversity in the collections, thus facilitating rationalization of these collections as well as avoiding redundancy on a national and international level. Incorporation of characterization and (preliminary) evaluation results in the national and international databases is a prerequisite. The activities under this objective are a necessary and integral part of the project and so are included here for completeness. Funding will continue to be provided by agencies other than CFC.

Activity 2.1.1

During the life of the project, more opportunities for collection and conservation of material from interesting new areas for wild cocoa will arise because of the existence of the project. Funds, as appropriate, will be identified for such activity, from other sources and material collected will be moved into international base collections after passing through quarantine and treated in the same way as existing germplasm.

Activity 2.1.2

Development and implementation of the most efficient, co-ordinated and cost-effective conservation and management procedures in national and international germplasm collections. Through the International Cocoa Germplasm Database it will be possible to assist in the identification of redundant accessions and errors in each of the collections and to improve the efficiency of the conservation effort.

Activity 2.1.3

Strengthening of already initiated characterization and preliminary evaluation activities in international, as well as national collections, using a minimum set of international agreed agronomically and botanically interesting descriptors. Such descriptors consist predominantly of visual measurements or estimations of vigour and yield, disease and pest incidence in the field, as well as fruit and seed characters. Wherever possible, such observations will be gradually replaced by molecular techniques, especially for botanical traits, and thus increase accuracy as well as to (hopefully) decrease cost. This effort will be enhanced by better international co-ordination.

Activity 2.1.4

Preliminary evaluation of the genetic diversity present in national and international collections by using isozyme and/or DNA marker technology. Priority will be given to those genotypes, within genetically distinct populations, that exhibit interesting agronomic or resistance traits (as evaluated under Activity 2.1.3). This activity will be strengthening of human capacity in the various disciplinary areas of cocoa breeding and conservation.

Activity 3.1.3

Preparation of annual progress reports as well as final reports by the individual locally responsible researchers and comprehensive project progress and final reports by the Scientific Co-ordinator.

Output 3.2: Mechanisms put in place to allow effective communication between participants.

Through the workshops, the project will achieve standardized evaluation and selection procedures; information on available germplasm and project results will be disseminated through working documents, in Newsletters, via publications and by introduction of data into databases.

Activity 3.2.1

Organization of two workshops, one approximately six months after project initiation and one during the fifth year, with participation of at least one responsible researcher from each participating country or institution being funded. During the first workshop standardized procedures for evaluation and selection of cocoa genotypes will be discussed and adopted, individual country workplans discussed and agreed upon, and the planned collaborative/activities between participants established. During the second workshop, project results will be presented and possibilities and procedures for project continuation discussed. Because of the perennial nature of the cocoa crop, it can be anticipated that a consolidation of the project outputs through continued breeding, selection and conservation activities in a second phase could be highly desirable.

Activity 3.2.2

Information on the project will be given in existing newsletters, exited by INGENIC, by the Cocoa Research Unit in Trinidad, by the International Cocoa Germplasm Database and by the Reading Quarantine facility.

Activity 3.2.3

Preparation of information sheets, including photographs of clones which are included in the international clone trials and of other distributed clones. Preparation of audio-visual material in support of the application of standard protocols, especially for vegetative multiplication of germplasm and application of disease resistance tests.

Activity 3.2.4

Co-ordination of the statistical analyses of the research data and provision of feedback to participants. Introduction of data generated by the project into national and international databases, especially into the International Cocoa Germplasm Database held at the University of Reading, UK. Updated versions of the latter database will be regularly

Objective 3

To strengthen cocoa germplasm utilization and conservation activities through scientific/technical backstopping, information exchange and human capacity building

Output 3.1: Functional linkages established between participating national and international programmes through scientific/technical backstopping, co-ordination and human capacity building.

This **output** provides the means and procedures to the participating institutions to communicate with each other and co-operate in the various activities. Because of the complexity of the project, it will be indispensable to establish a co-ordinating body for technical and administrative matters. In addition, technical and scientific backstopping to the participating institutions, where needed, will allow these partners to carry out the agreed programme as soon as possible independently.

Activity 3.1.1

The **scientific/technical backstopping and co-ordination** of project activities has the following elements:

- Ensure that there is a co-ordinated implementation of evaluation and breeding activities in accordance with the project objectives, through close co-operation with all participating institutions and individual scientists;
- Assist national and international cocoa germplasm collection managers/curators, as required, to improve conservation and management procedures and suggest ways and means for rationalization of their collections;
- In close co-operation with interested/experienced researchers, analyze suitability of the procedures and adjust/improve these where necessary for characterization, preliminary evaluation and selection activities to ensure results are internationally comparable;
- Co-ordinate the production, multiplication and distribution of the genetic material involved in the breeding trials, in collaboration with the institutes concerned;
- Stimulate the regular exchange of information between the participants on procedures and project results;
- Yearly working visits to participating countries by the Scientific Co-ordinator to review project activities, to discuss technical constraints and to discuss matters related to cocoa germplasm conservation and utilization are anticipated.

Activity 3.1.2

Through the exchange of information, discussions during visits of the Scientific Co-ordinator and during workshops, through targeted short training activities (such as on-the-job training) and through technology transfer, inputs will be made into the parents and offspring. This permits to demonstrate, on the basis of a limited population, the way to obtain long-term progress in cocoa breeding, namely through application of alternate clone and hybrid selection (first cycle of recurrent selection).

Recurrent selection applied to distinct populations is proposed in those countries that possess large enough genetic variation in their collections and enough breeding experience to be able to initiate this approach successfully in order to obtain continuous long-term selection progress.

The above outline explains how the various trials are technically linked to one or more different project element(s). Efficient coordination is essential to ensure that these links are functionally applied, thus offering the best opportunity of attaining the intermediate project objective, i.e. to produce new cocoa varieties with better yield, resistance to diseases and pests, and well adapted to local conditions.

distributed to all participants Funds for the on-going support of the International Cocoa Germplasm Databases are assured for the foreseeable future.

Output 3.3: Formation of an informal network between participating scientists and institutions.

This output will facilitate the exchange of information between all parties involved in the project as well as with others interested in participating. The use of electronic communication means will greatly facilitate this exchange, thus enhancing the evaluation and breeding activities and avoiding duplication of effort while adding to the complementarity of the research.

Activity 3.3.1

The project coordination unit, with support from the Executing Agency through its world-wide office network, will provide the necessary input for the operation of this informal network. The established communication channels will also greatly facilitate the other coordination activities of the project.

G. SCIENTIFIC AND TECHNICAL PROBLEMS AND THEIR RELATIONSHIP

The scientific background and project justification have been presented in detail in Chapter C and partly in Chapter D. The technical problems addressed by each output have been presented together with the description of the specific objectives in Chapter F. Hereafter, the functional relationship between the different project elements is outlined in relation to general cocoa conservation and utilization procedures (also see Fig. 1).

The proposed cocoa conservation and characterization activities are linked to the existing national and international base collections of cocoa, providing new stimuli to evaluation and use of selected germplasm, among others, through the identification of a "core collection". This activity is directly related to the germplasm enhancement/or pre-breeding activities, which aim at improving germplasm of base collections for specific traits, increasing its potential value for user countries.

The international clone selection trial aims at distribution to user countries of new interesting cocoa genotypes maintained in base collections or presently available in quarantine centres. These trials permit the evaluation of interesting genotypes on the stability for economic traits in different environments, a basic element to consider in further regional and international cooperation in cocoa genetic improvement. These trials simultaneously stimulate selection of cocoa clones, little practiced so far in many countries though considered genetically the most efficient way to improve the cocoa crop in the short-term.

The international hybrid trial, as well as permitting varietal outputs, is directly linked to the clone trial, as the hybrid families are created by intercrossing selected genotypes evaluated in the clone trial. This approach will permit to verify the relationship between

H. ECONOMIC AND FINANCIAL JUSTIFICATION

Although there are no precise estimates for the annual loss of cocoa production due to diseases, this is estimated to be in the range of 20-40 percent of world production. Pests also cause substantial additional losses, but these are even more difficult to estimate. The costs of control of both pests and diseases is substantial, but it is also impossible to offer any precise figures for these annual costs. In the light of these uncertainties, it is not feasible to make any detailed economic projection of the benefits which can be generated from the Project.

As mentioned earlier, the new generation of planting material which arises from the work of the Project will have greater resistance to one or more of the serious diseases of cocoa which currently cause such devastation across a wide geographical area. Assuming that the improved disease resistance arising from the work of the Project was able to reduce the loss of world cocoa production from diseases by an annual amount of only two percent[13] (equivalent to 54,316 tonnes per annum), then this will increase the revenue accruing to cocoa producers by an amount of USD 74.5m per annum[14]. On the basis of this calculation, the investment in this project to provide improved planting material for cocoa smallholders must be viewed as beneficial and providing an opportunity for an improved rate of return.

I. SOCIAL IMPACT

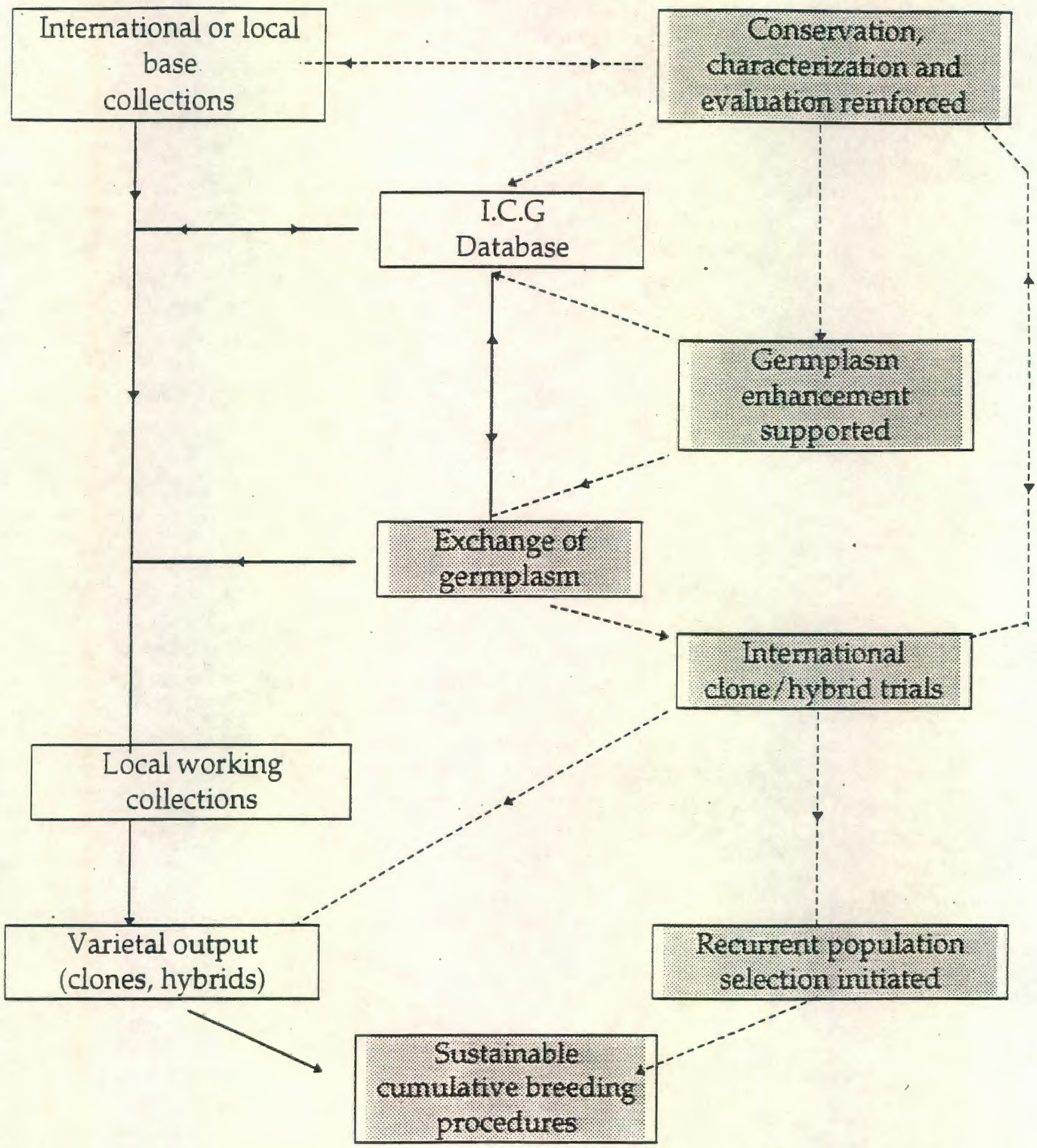
As indicated earlier, average global yields of smallholder cocoa have increased little in recent decades. The identification of improved planting material for such farmers - and thus for a higher percentage of the world's cocoa growers - would offer them enhanced income from a smaller area of land thereby releasing land for the growing of other export crops or for food production, thus potentially offering a significant social benefit. It is also anticipated that social (and environmental) benefits will be derived from reduced fungicide, and possibly, insecticide usage.

Substantial benefit will be derived by the economies of cocoa producing countries due to the lower cost base expected from use of improved planting material with higher disease resistance.

J. ENVIRONMENTAL IMPACT

Cocoa is a permanent tree crop usually with a forest canopy of shade growing in the equatorial rainforest belt and thus providing good soil and environmental protection. The establishment of the fields using improved planting material arising from the project is anticipated to offer better disease (and possibly pest) resistance leading to lower overall use of fungicides and pesticides thereby benefiting the environment.

Fig. 1.Functional links (- - - -) between project activities (shaded boxes) and general cocoa improvement procedures (—)



- Segregating populations created and early selection applied for disease resistance (germplasm enhancement and population breeding activities, (2nd to 5th year).

- Newly selected genotypes or seed populations transferred to interested user countries (2nd to 5th year).

- International coordination mechanisms established.

- Information on cocoa clones exchanged and stored in international databases.

- Training activities implemented.

The chronological execution of project activities is indicated in Table 1. The distribution of responsibilities over the various institutions is presented in Chapter O.

K. WORKPLAN

In order to implement the project in a harmonious and concerted way, it is planned to undertake several co-ordinating and consultation steps as the first project activities during the initial phase of the project. These initiatives will include, among others:

a) Soon after the starting date, visits to participating institutions by the Scientific Co-ordinator will be needed to discuss individual work programmes and devise detailed budgets for agreement;

b) In order to obtain comparable results procedures will be developed with the individual researchers to be applied to characterization, preliminary evaluation and selection activities that require standardization;

c) Identification of genetic material to be included in the international clone and hybrid trials, in collaboration with the institutes concerned;

d) Organization of a workshop .vithin 6 months after project initiation to discuss the above and adopt standardized working procedures for the following elements: characterization and evaluation of germplasm, vegetative propagation procedures, disease resistance screening, field observations, statistical design and crossing schemes to be applied to breeding and selection trials;

e) Co-ordination of production and multiplication of genotypes to be used in the international clone trial;

f) Preparation of a Letter of Agreement with each participating institute, indicating the type of services that will be carried out by these institutes and detailed costs involved following the projected average figures as indicated in the general budget.

It is also planned to organize a meeting on the occasion of the 12th International Cocoa Research Conference in November 1996, which will be attended by most of the institutions that have expressed their interest in the present project proposal, in order to discuss general project implementation procedures.

Milestones in the project implementation are:

- Standardized working procedures discussed and approved (1st year).
- 25 selected clones transferred from quarantine centres to user countries (1st and 2nd year).
- Internationally co-ordinated clone and hybrid trials planted in 10 countries (2nd and 3rd year)
- Genotypes with increased disease resistance identified in base collections (1st to 3rd year).

L. PROJECT INPUTS

Details of project inputs are included in the calculations of the unit costs for each of the main project activities as part of Chapter N., and can be found in Appendix V. The information in this Appendix will also show how the inputs are related to the different elements of the workplan. However, since the unit costs presented are based on an average it will be necessary to arrive at specific budgets individually with each participating country during the first six months of the project, which will be reflected in the Letters of Agreement between the Executing Agency and the participating countries and institutions.

M. RISKS

Three type of risks are identified.

First, many of the project activities rely heavily on counterpart contributions, whereas the CFC funds mainly cover running costs. Local research and funding systems are subject to fluctuations that cannot be foreseen at the moment, therefore activities in some countries may possibly receive insufficient counterpart financing needed for optimal project execution. For this reason some of the key activities have been distributed over a relatively large number of sites, to ensure that sufficient valuable information is generated.

Second, it should be realized that due to the perennial nature of the cocoa crop, full exploitation of the results will only be possible in a second phase of the project (6th-10th year). For example, the multilocational clone trials are expected to be planted during the second and third year of project implementation. Although the project envisages application of early screening methodology for some traits, it is clear that important agronomic traits, like yield and field resistance to diseases, can only be correctly evaluated by 5-7 year observations after planting, which is not guaranteed by the present project duration. However, the nature of the key activities of the project is such that these, after having been established, are likely to be continued even with reduced financing in the event that the project is not extended into a second phase.

Third, as is justified by the background information herein, an important project objective is identification and selection of disease resistant cocoa genotypes. The international approach of the project offers a unique opportunity to evaluate stability of resistance in different countries and in relation to pathogen isolates from different sites (the latter by centralized resistance tests). These evaluations rely partly on the application of early screening tests that have been developed rather recently in some of the participating institutions for two major diseases, black pod and witches' broom. The project, as designed, will permit to evaluate the repeatability of the early screening tests when carried out by different persons in different countries, which is presently unknown. Although this aspect represents a possible risk in relation to the successful application of these tests in cocoa breeding, the training aspect and information generated by the standardized application of these tests in many different countries would in itself justify this approach.

It is **assumed** that the participating countries and institutions are willing and able to exchange relevant information as well as genetic material, although the latter cannot be conditioned because of the national sovereign rights of states over the biodiversity within its borders.

N. PROJECT BUDGET

1. Project income

The total cost of the proposed activities is estimated at US$10,373,000. Of this total an amount of US$5,125,000 is estimated as counterpart contributions to the project. Counterpart contributions are herewith defined as contributions (either in kind or in cash), made by the participating international and national genebanks or by the research institutes for activities which will be relevant to the project (in some cases these are a continuation of existing contributions). In the case of participating national research programmes, this expenditure includes inputs and provisions which are essential to implement the project activities and must be secured for project implementation.

A significant amount, i.e. US$2,300,000, will be made as co-financing contributions to the project by various partners. Co-financing is herewith defined as specific expenditures in cash or in kind made by participants to implement certain project activities. These contributions will only be guaranteed if CFC funding is secured to implement the project. ACRI, BCCCA and CIRAD have agreed to provide co-financing to the activities outlined in the General Budget Table (Table 2.1 in US$, 2.2 in SDR).

A total of US$2,948,000 is requested from the Common Fund. The proposed contribution of the Fund mainly relates to selection and breeding activities and to information exchange, coordination and project management. The distribution of the requested funds and estimated counterpart contributions, according to the general activities of the project, are indicated in the General Budget Table (Table 2.1 in US$, Table 2.2 in SDR).

Table 2.1 General Budget in US Dollars (000 US$) by main project activities

Item No.	Item/Activity	Institutions	Counter-part	Co-financing	CFC
1	International clone trial (9 sites)	Nat'l Research Centres CIRAD Imperial College	450 50 50		450 50 75
2	International hybrid trial (5 sites)	Nat'l Research Centres	250		200
3	Germplasm evaluation and enhancement (2 sites)	CRU ACRI BCCCA CIRAD	150 230 	 150 100 500	200
4	Population breeding (4 sites)	Nat'l Research Centres CIRAD ACRI	600	 250 150	600
5	Conservation, management and characterization of available germplasm	CRU BCCCA ACRI CIRAD Nat'l Research Centres	500 820 300	 100 250 500 	
6	Multiplication, distribution and quarantine of genotypes	CRU CIRAD Reading Univ/BCCCA BCCCA	150 100 300	50	43 42 44
7	Exchange of information, 2 workshops, publications	All participants ICDG/LCE/BCCCA	200 300		200
8	Scientific/technical backstopping and coordination	IPGRI CIRAD Others (as consultants)	275 200	100 150	575
9	Overheads (10%)	IPGRI			248
10	Supervision and project evaluation	ICCO and CFC			75
	Sub-totals		4,925	2,300	2,802
11	Contingencies (5%)	All participants			140
	TOTAL		**4,925**	**2,300**	**2,942**

Table 2.2 General Budget in SDR by main project activities

Item No.	Item/Activity	Institutions	Counter-part	Co-financing	CFC
1	International clone trial (9 sites)	Nat'l Research Centres CIRAD Imperial College	310 34 34		310 34 52
2	International hybrid trial (5 sites)	Nat'l Research Centres	172		138
3	Germplasm evaluation and enhancement (2 sites)	CRU ACRI BCCCA CIRAD	104 159 	 104 69 345	138
4	Population breeding (4 sites)	Nat'l Research Centres CIRAD ACRI	414	 172 103	414
5	Conservation, management and characterization of available germplasm	CRU BCCCA ACRI CIRAD Nat'l Research Centres	345 565 207	 69 172 345 	
6	Multiplication, distribution and quarantine of genotypes	CRU CIRAD Reading Univ/BCCCA BCCCA	104 69 207 	 34	30 29 30
7	Exchange of information, 2 workshops, publications	All participants ICDG/LCE/BCCCA	138 207		138
8	Scientific/technical backstopping and coordination	IPGRI CIRAD Others (as consultants)	190 138	69 104	396
9	Overheads (10%)	IPGRI			171
10	Supervision and project evaluation	ICCO and CFC			52
	Sub-totals		3,397	1,586	1,932
11	Contingencies (5%)	All participants			97
	TOTAL		3,397	1,586	2,029

Details of the individual budget items concerning CFC funding are given in Appendix III (IIIA in US$, IIIB in SDR), and the breakdown of costs per project activity is indicated in Appendix V. These activities will be carried out as services to be contracted by the Project Executing Agency (IPGRI). Further breakdown of costs per project site will be included in the Letters of Agreement to be prepared during the first months of the project between IPGRI and all participating institutions.

2. Project costs

The costs as indicated in the General Project Budget (Tables 2.1 and 2.2), are broken down in Appendix IV with regard to the activities to be financed by the Fund. As mentioned in Chapter L, these calculations are based on average unit costs as estimated from information obtained from the interested countries and institutes. As an example, the average costs for preparation and maintenance of one hectare of cocoa trial land has been estimated to be 2,000 US$ per year.

As indicated previously, a large part of the detailed project costs can be indicated only when the Letters of Agreement have been elaborated, specifying the services to be executed by each institution. Below are the general costs to be covered by CFC funding, according to the items indicated in the Manual for Project Preparation and based on the breakdown of costs given in Appendix V.

a. Personnel costs (corresponds with part of item 8 in Table 2)

Senior Scientific/Technical Coordinator (to be recruited internationally, possibly in combination with one of the major research institutions involved):

• Yearly CFC contribution (US$)	80,000
Total over 5 years	**400,000**

b. Duty travel (part of item 8, Table 2)

• Duty travel for general coordination purposes, yearly	6,000
• Duty travel for scientific/technical coordination, yearly	24,000
Total over 5 years	**150,000**

c. Statistical analyses, etc. (part of item 8, Table 2)

Total over 5 years	**25,000**

d. Contracts and services (items 1,2,3,4 and 6)

• International clone selection trials	575,000
• International hybrid trials	200,000
• Germplasm enhancement	200,000
• Population breeding	600,000
• Multiplication and distribution of germplasm	129,000
Total over 5 years	**1,704,000**

e. **Non-expendable equipment**

No costs for non-expendable equipment are foreseen.

f. **Expendable supplies**

These will be specified in the Contract and Services agreements (point d)

g. **Disseminating of results and workshops** (item 7, Table 2)

• Information exchange, publications (yearly)	10,000
• 2 workshops (1st and 5th year), each	150,000
Total over 5 years	**200,000**

h. **Project management costs** (items 9 and 10, Table 2)

• Overhead costs	248,000
• Supervisory Body expenses	27,000
• 2 CFC evaluation missions	48,000
Total over 5 years	**323,000**

i. **Other expenses**

No other expenses foreseen

j. **Contingencies** (item 11, Table 2)

Calculated as 5% of project costs, yearly	28,000
Total over 5 years	**140,000**

O. COLLABORATING INSTITUTIONS AND MANAGEMENT

1. Institutions involved

Participating national institutions

The following national cocoa research institutions involved in cocoa breeding and selection have requested participation in one or more activities of the project:

Africa:
Institut de Recherche Agronomique pour le Developpement (IRAD), Cameroon
Institut des Forets (IDEFOR) Departement Cafe-Cacao et autres Plantes Stimulantes (DCC), Ivory Coast
Cocoa Research Institute (CRI), Ghana
Cocoa Research Institute of Nigeria (CRIN)

America:
Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Brazil
Instituto Nacional de Investigaciones Agropecuarias (INIAP), Ecuador
Ministry of Agriculture, Land and Marine Resources, Trinidad and Tobago;
Fondacion Nacional de Investigaciones AgroPecuarias, Venezuela

Asia:
Malaysian Cocoa Board, Malaysia
PNG Cocoa & Coconut Research Institute, Papua New Guinea

International Cocoa Germplasm Centre

CRU, Trinidad and Tobago. Largest international cocoa germplasm collection; active research programme linked with University of the West Indies (characterization and evaluation of cocoa germplasm, phytopathology, disease resistance screening, molecular techniques); in-ward quarantine facility in Barbados; under Graduate and post Graduate courses (M. Phil. and Ph.D.) as part of the University of the West Indies.

Cocoa Research and Quarantine Centres

CIRAD-CP, France. Long-term experience in cocoa breeding research; has quarantine facilities at Montpellier; undertaking research on cocoa genetic diversity using molecular markers, *in vitro* multiplication, disease resistance screening, has cocoa conservation and characterization activities in French Guyana; maintains co-operative cocoa research activities with CRU, Côte d'Ivoire, Cameroon, Sao Tomé and Ecuador. Project support institution.

The University of Reading, UK. Operating an Intermediate Cocoa Quarantine Facility; research capacity and experience on physiological aspects. Institution whose participation is partially supported by co-finance.

International Cocoa Germplasm Database (ICGD). Supported by the London Commodity Exchange and by the University of Reading. ICGD has freely distributed printed and computerized versions of the database. It contains information on the origin of approximately 5,000 clones, lists accessions present in 43 genebanks and contains some characterization and evaluation data for 3,600 clones.

Imperial College at Silwood Park, Ascot, (or another suitable institution) **UK.** Large experience in laboratory evaluation of resistance to witches' broom disease with a unique collection of isolates of the pathogen; therefore in a unique position to screen candidate material against a range of isolates.

Research Co-ordinating and Funding Partners

ACRI, USA: Research donor - supported by US cocoa processors and chocolate manufacturers. Currently supports work on : cocoa quality, biotechnology, productivity and pathology aspects; research co-ordination experience. Project co-financing institution.

BCCCA, UK: Research donor - supported by UK cocoa processors and chocolate manufacturers. Currently supports work on : cocoa germplasm characterization, evaluation and use; research co-ordination experience. Project co-financing institution.

CAOBISCO, Brussels: Research donor - supported by European cocoa processors and chocolate manufacturers. Currently supports work on : ***Phytophthora*** screening.

Cocoa Producers' Alliance (CPA): CPA is an inter-governmental body of cocoa-producing countries with headquarters in Nigeria. Its objectives are to exchange technical and scientific information, to discuss problems of mutual interest, and to advance social and economic relations between producers. They also aim to ensure adequate supplies of cocoa to the market at remunerative prices and promote cocoa consumption.

International Group for Genetic Improvement of Cocoa (INGENIC): This informal group was created in 1994 with the objective to promote exchange of information and international collaborative research in the area of cocoa genetics and breeding. It publishes a newsletter and held its first International Workshop on Cocoa Breeding Strategies in October 1994 in Kuala Lumpur and published the proceedings. A second workshop is to be held in November 1996 in Salvador, Brazil with the theme "Contribution of Disease Resistance for Cocoa Varietal Improvement". INGENIC operates with *ad hoc* funding from different donors and has an Executive Committee consisting of five members.

2. The Project Executing Agency

The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR) and was established in 1991 as the successor institute of IBPGR. IPGRI's **mandate** is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI's **mission** is to encourage, support and engage in activities to strengthen the conservation and use of plant genetic resources world-wide, with special emphasis on the needs of developing countries. IPGRI works in partnership with other organizations, undertakes research and training and provides scientific and technical advice and information. The international status of IPGRI is conferred under an Establishment Agreement which, to date, has been signed by the Governments of 45 countries.

IPGRI's organizational structure comprises of eight programme groups, five regional and three thematic. The Regional Groups are based, and co-ordinate IPGRI's work in: **Sub-Saharan Africa; West Asia and North Africa; Asia, the Pacific and Oceania; the Americas, Europe**. The three Thematic Groups at Headquarters in Rome are responsible for developing and co-ordinating research and information work of inter-regional or global relevance in their respective subject areas and are also responsible for providing scientific and technical support to the regions.

IPGRI has a staff whose expertise spans most of the fields of genetic resources science and technology. Through its network of Regional Offices, IPGRI has established working relationships with almost all of the active crop, forestry/agroforestry and forage genetic resources programmes in the world. IPGRI has continuing working relationships with relevant UN agencies and with major international NGOs concerned with conservation and agricultural development.

The Project Executing Agency will be responsible for the overall co-ordination of the project, provide scientific and technical backstopping and will facilitate the exchange of information and germplasm. IPGRI is prepared to assume the responsibility of Executing Agency, as suggested by the institutions involved in project preparation to date, if adequate funds can be made available. Furthermore, it will seek the scientific and technical expertise on cocoa breeding and production from other institutions, such as CIRAD-CP and the University of Reading, to ensure that the project participants have access to the best inputs available in these areas.

The co-operative approach related to the specific project objectives and outputs will be discussed in more detail between the project co-ordinating unit and participating institutions during the first six months of project implementation.

It is envisaged to establish an informal world-wide network of cocoa breeders, researchers and curators to foster communication and co-operation. The project co-ordinating unit will facilitate the network in various ways and, for the time being, provide it with the necessary infrastructure.

3. *Project activities and participating/contributing institutions*

Project Activity	Participating Institutions
a) International clone trials	National programmes (trials at 9 sites, distribution of clones to other sites)
b) International hybrid trials	National programmes (5 sites)
c) Population breeding	National programmes (4 sites)
d) Germplasm enhancement	CRU
e) Germplasm conservation	CRU, national programmes, IPGRI
f) Germplasm characterization	CRU, CIRAD, some national programmes
g) Germplasm screening	CRU, CIRAD, some national programmes
h) Germplasm exchange and quarantine	CRU, CIRAD, Reading University, national programmes
i) Coordination	IPGRI
j) Technical/scientific backstopping	IPGRI, CIRAD, consultants
k) Training	IPGRI, CRU, CIRAD, national programmes
l) Centralized statistical and laboratory analyses	CIRAD, Imperial College
m) Networking	IPGRI, all participants
n) Information management and distribution	CRU, ICGD (database), national programmes, IPGRI, CIRAD

The proposed distribution of the internationally co-ordinated evaluation and breeding activities over the different project sites is indicated in the Appendix II.

P. THE SUPERVISORY BODY

International Cocoa Organization (ICCO)

The International Cocoa Organization, as the sponsoring International Commodity Body (I.C.B) will take on the role of Supervisory Body for the project.

In this role, it will supervise and monitor the project and will examine all information submitted to it by the Project Executing Agency (PEA), IPGRI, pertaining to the implementation of the project.

It will assess whether the actions undertaken, the expenditures made and the results achieved by the PEA conform to the project specifications as agreed.

It will monitor the continued relevance of proposed project activities and the prospects for the project's successful completion.

Q. MONITORING, REPORTING AND EVALUATION

Brief informal quarterly progress reports will be submitted to the Project Executing Agency to inform about the ongoing activities and possible problems encountered. More extensive and formal six-month and annual progress reports will be prepared by the participating institutions, including all the data obtained. It is foreseen to establish a simple communication tool (i.e. a newsletter) to quickly disseminate any relevant information to all participants. Based on these reports, co-ordinators of the project will distribute these reports to all partners and prepare ~~a~~ general annual report according to the different project activities, which will be forwarded to ICCO and CFC.

Two joint review missions organized by CFC and ICCO are planned, to be realized in the 3rd and 5th year of project implementation. The experts will visit a number of key project sites and participate in the workshop to be realized during the first and the fifth year.

R. ENDNOTES

1. ICCO communication to IPGRI on 7 Oct., 1994. ICCO draft global strategy for cocoa.

2. In this context a smallholder is defined as a grower with less than 40 ha; many small farmers in West Africa have 1 ha of cocoa or less.

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9. Lanaud, C., Risterucci, A.M., N'Goran, J.A.K., Clement, D., Flament, M.H. and Laurent, V. 1995. A Genetic Linkage Map of Theobroma cacao L. Theo. Appl. Genet., 91, pp.987-993.

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11. Engels, J.M.M. and Dyce, G. 1994. Evaluation Report of the Cocoa Research Unit Trinidad, Phase II, Project No.7-ACP-RPR-201 financed by the European Economic Community, IPGRI, Rome, Italy (unpublished).

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APPENDICES

APPENDIX I Abbreviations of institutions

BCCCA	The Biscuit, Cake, Chololate and Confectionary Alliance, UK
CAOBISCO	Association of the Chocolate, Biscuit and Confectionary Industries in the EC, Belgium
CATIE	Centro Agronomico Tropical de Investigacion y Enseñanza, Costa Rica
CFC	Common Fund for Commodities, The Netherlands
CIRAD	Centre de Cooperation International en Recherche Agronomique pour le Developpement, France
CPA	Cocoa Producers Alliance, Nigeria
CRU	Cocoa Research Unit, Trinidad and Tobago
IBPGR	International Board for Plant Genetic Resources
ICB	International Commodity Body
ICCO	International Cocoa Organization, UK
ICGD	International Cocoa Germplasm Database, University of Reading, UK
IPGRI	International Plant Genetic Resources Institute, Italy
LCE	London Commodity Exchange, UK
PEA	Project Executing Agency
SDR	Special Drawing Rights

APPENDIX II: Proposed distribution of internationally coordinated evaluation and breeding activities over project sites, subject to final formal confirmation of countries/institutions

Country/Site	Activity			
	Clone evaluation and selection*	Hybrid trials	Population breeding	Germplasm enhance-ment
America:				
Venezuela	X	X		
Trinidad	X			
Ecuador	X	X		
Brazil	X		X	
Africa:				
Côte d'Ivoire	X		X	
Ghana	X		X	
Nigeria	X	X		
Cameroon	X	X		
Asia:				
Malaysia			X	
PNG	X	X		
Germplasm Centre:				
CRU				X
Total	9	5	4	1

* "X" indicates clone trials with 6 replications, including locally selected clones;

APPENDIX IIIA: Detailed budget items in US Dollars for CFC funding by activity and year (000 US$)

ITEM	Year: 1	2	3	4	5	TOTAL
Clone trials	115	115	115	115	115	575
Hybrid trials	40	40	40	40	40	200
Germplasm enhancement	40	40	40	40	40	200
Population breeding	120	120	120	120	120	600
Conservation and characterization	-	-	-	-	-	-
Multiplication and distribution of germplasm	49	20	20	20	20	129
Scientific/technical coordination and backstopping including travelling	115	115	115	115	115	575
Information exchange workshops, publications	10	10	85	10	85	200
Overheads	49	46	53	46	53	248
Supervision + evaluation	5	5	30	5	30	75
Contingencies	27	26	31	26	31	140
TOTAL	**570**	**537**	**649**	**537**	**649**	**2942**

APPENDIX IIIB: Detailed budget items in SDR for CFC funding by activity and year (000 SDR)

ITEM	Year: 1	2	3	4	5	TOTAL
Clone trials	79.3	79.3	79.3	79.3	79.3	396
Hybrid trials	27.6	27.6	27.6	27.6	27.6	138
Germplasm enhancement	27.6	27.6	27.6	27.6	27.6	138
Population breeding	82.8	82.8	82.8	82.8	82.8	414
Conservation and characterization						
Multiplication and distribution of germplasm	33.8	13.8	13.8	13.8	13.8	89
Scientific/technical coordination and backstopping including travelling	79.3	79.3	79.3	79.3	79.3	396
Information exchange, workshops, publications	7	7	59	7	59	138
Overheads	34	31.7	36.6	34	36.6	171
Supervision + evaluation	3	3	1	3	21	51
Contingencies	18.6	17.9	21.3	17.9	21.3	98
TOTAL	**393**	**370**	**448**	**370**	**448**	**2,029**

APPENDIX IV: Breakdown of costs per project activity and budget item (US$)

A. Estimate of average unit costs for implementation of specific project activities (US dollars). The actual costs, however, may vary slightly between project sites, as will be indicated in the Letters of Agreement to be prepared with each site.

• Preparation of land, planting and maintenance costs	$2,000 per ha per year
• Multiplication of clones and nursery costs	$1 per plant
• Screening tests for disease resistance (black pod, witches' broom),	$25 per progeny/clone
or,	$3 per field plant
or	$2 per nursery plant
• Field observations	
- agronomy traits	$500 per ha per year
- resistance traits	$1,000 per ha per year
• Realization of pollination and raising seedlings in the nursery	$.50 per seedling
• Shipment of courier packages for distribution of germplasm	$100 per package 2.5kg.

B. Breakdown of average total costs for each budget item per site

1. Clone trial and selection

1.1 Realization of clone trial and local evaluation of disease resistance (part of item 1, Table 2)

a. Reception and multiplication of clones in the nursery; production of 5,000 grafted plants	5,000
b. Early screening for disease resistance (200 progenies/ clones)	5,000
c. Preparation of land, field plantings maintenance (4 ha, 4 years)	32,000
d. Field observations (4 years)	8,000
Total per site	**$ 50,000**
Total of trial at 9 sites	**$450,000**

1.2 Centralized evaluation at two sites (UK, France) of resistance of 25 clones to blackpod and witches' broom using 10 isolates and 5 isolates, respectively.

1.2.1 CIRAD, France (part of item 1, Table 2)

a. Laboratory assistant (9mths.)	30,000
b. Greenhouse assistant (2days/week/year)	7,000
c. Consumables	4,000
d. Maintenance costs of greenhouse (50sq.mts,1 year)	7,000
e. Maintenance costs of growth chamber (1 year)	2,000
Total	**$50,000**

1.2.2 Imperial College, Silwood Park UK (part of item 1, Table 2)

a. Salary (post doc.) 1 year	38,000
b. Maintenance of cultures - inocculum preparation	15,000
c. Glasshouse rental	7,500
d. Expendable items	7,000
e. Contingency (overheads imposed by University)	7,500
Total	**$75,000**

2. Hybrid trial (item 1, Table 2)	
a. Pollination, nursery costs for 4,000 seedlings	3,000
b. Land preparation, planting and maintenance (2.5ha)	24,000
c. Resistance screening on field and nursery plants (80 progenies/clones; 3,000 seedlings)	8,000
d. Field observations (4 years)	5,000
Total per site	**$ 40,000**
Total of hybrid trial and 5 sites	**$200,000**

3. Germplasm enhancement (item 3, Table 2 on 1 site)	
a. Field evaluation for resistance and agronomic traits in existing collections or trials (10 ha, during 5 years)	75,000
b. Screening tests (pods, leaves) on 500 entries (clones) per year during 5 years	62,500
c. Pollination and nursery costs (5,000 seedlings/year)	12,500
d. Screening of nursery seedlings (200 progenies and 10,000 individual plants)	25,000
e. Field planting and observations (2ha, for 3 years)	15,000

f. Consumables for transport, small materials	50,000
g. Assistants for screening and evaluation activities (2 field and 2 laboratory assistants) 4 x 8,000x 5	160,000
Total	**$200,000**
4. Population breeding (item 4, Table 2)	
a. Evaluation of parental material in the field for agronomic and resistance traits (5 ha, 3 years)	22,500
b. Laboratory screening of field plants for resistance (total 300 progenies/clones and 4,000 individual trees)	19,500
c. Pollination and nursery costs (total 18,000 seedlings)	9,000
d. Early screening for resistance of 300 nursery progenies/clones and 5,000 seedlings	17,500
e. Field planting and maintenance (6.5 ha, 3 years)	39,000
f. Multiplication of 25 selected clones in the nursery, preparation of 5,000 grafted plants	5,000
g. Salary of one assistant for screening and evaluation Yearly salary $7,500, five years	37,500
Total per site	**$150,000**
Total of population breeding at 4 sites	**$600,000**

5. Conservation and characterization of internationally available germplasm. No CFC funds, only counterpart and co-financing.

6. Distribution and quarantine (item 6, Table 2)	
a. Multiplication of budwood of 25 clones to be sent to 9 sites, total 2,000 budsticks	10,050
b. Shipment of budwood; 200 packages by courier	13,500
c. Postage, faxes and telephone costs	7,500
d. Intermediate quarantine services occupying 200m greenhouse space for 3 years, maintenance costs	59,750
e. Assistant for 12 months for multiplication of budwood and maintenance of clones	37,500
Total for multiplication and quarantine	**$128,300**

	CIRAD	University of Reading	CRU	Total
a.	4,200	2,250	3,600	10,050
b.	6,000	2,500	5,000	13,500
c.	2,000	2,500	3,000	7,500
d.	15,000	13,750	31,000	59,750
e.	15,000	22,500	-	37,500
	42,200	43,500	42,600	128,300

7. Scientific/technical backstopping and coordination (item 8, Table 2)

a. Salary for a senior scientific coordinator 400,000

b. Travel costs to visit project sites once a year:
- daily subsistence for 92 days per year x $125 for 5 years: 57,500
- 6 flight tickets/year to visit sites in Central America, South America, Africa and Asia ($3000/ticket) 90,000
- visas, taxes etc. 2,500

c. Statistical analyses, etc. 25,000

Total **$575,000**

8 Exchange of information, realization of workshops (item 7, Table 2)

a. Preparation of photographs of distributed clones (by ICGD), training material, distribution of reports 20,000

b. Realization of two workshops, including travelling and daily subsistence for 20 participants ($4000 each) 160,000

c. Editing and printing of proceedings 20,000

Total **$200,000**

9. Overheads (10%) **$248,000**

10. Supervision and project evaluation

a. ICCO supervision (for details see Appendix V) 27,000

b. Two project evaluation missions (CFC) 48,000

Total **$ 75,000**

10. Contingencies (5%) of total project cost of US$3,199,000 **$140,000**

APPENDIX V. ICCO SUPERVISION COSTS IN THE GERMPLASM PROJECT

1. REGULAR REPORTING AND COMMUNICATIONS

This heading is based on the following assumptions:

1. two reports will be produced every year to the International Cocoa Council, each with an average of three pages, typed, translated into all four working languages[2] of the ICCO and printed:

2. communication costs (including, fax and electronic mail) to the PFA will be incurred to discuss various aspects of the project during its implementation.

Production of report ($570.00/report x 2) x 5	$ 5,700.00
Communications ($37.5/month x 12 months x 5 years	$ 2,250.00

Sub-total I: $7,950.00

II. MID-TERM REVIEW AND FINAL EVALUATION

This heading is based on the following assumptions:

1. One two-week trip for the mid-term review and another two-week trip for the final evaluation will be made by the ICCO Project Officer to visit three sites of implementation of the project (one site in the West African region, one in South-East Asia and another one in Latin America). For each region, two or three countries will be visited.

2. Two reports will be produced, one for each of these trips.

The costs of these trips and the production of the reports are calculated as follows:

Plane tickets $6,000 x 2	$12,000.00
Subsistence Allowance: $150.00/day x 14 days x 2 trips	$ 4,200.00
Production of Mid-term report (twice the cost of producing one mid-year report)	
$570.00 x 2	$ 1,1490.00
Production of the final report (3 times the cost of producing one mid-year report)	
$570.00 x 3	$ 1,710.00
Subtotal II: $19,050.00	
TOTAL $7,950.00 + $19,050.00	**$27,000.00**

[2] English, French, Spanish, Russian

APPENDIX VI: Proceedings of the International Workshop on Cocoa Breeding Strategies, held in Kuala Lumpur, October 1994, as published in the Proceedings and edited by INGENIC

CONCLUSIONS AND RECOMMENDATIONS OF THE INTERNATIONAL WORKSHOP ON COCOA BREEDING STRATEGIES*

Discussion by the participants of the ICWBS resulted in the following conclusions and recommendations.

1. There is increasing evidence that many quantitative traits of economic interest are inherited additively. The implication is that there should be more emphasis on phenotypic rather than genotypic evaluation as the basis for selection of parents as positive correlation can be expected, especially when mating related genotypes.

1. There is general acceptance that cocoa can be improved in a properly managed recurrent selection programme, which would exploit GCA and SCA effects.

3. Although there is little direct evidence in the literature for heterosis over the best parent for yield in wide crosses, there is evidence for inbreeding depression which is an indirect demonstration of heterosis.

4. There is growing recognition that efficient breeding for yield would benefit from improved understanding of cocoa physiology. Emphasis should be placed on canopy architecture, assimilate accumulation and partitioning, and optimum planting density. Improved methods are required for measuring physiological traits at the single tree level.

5. Many more breeders are paying attention to flavour. Progress is dependent on direction and commitment from the manufacturers and processors of cocoa.

6. There is also increasing attention to cocoa butter content. Although improvement is possible, the weighting for cocoa butter content in an economic selection index remains to be established.

7. The historic emphasis in direct breeding for pest and disease resistance is coming into question with the realization that rather limited progress has been made in many programmes. A new approach is needed in the light of recent work on the genetics of partial resistance to many diseases. The great importance of pest and diseases emphasizes the need to improve methodologies for the rapid and reliable measurement of expression of resistance.

8. The new biotechnologies offer new insights to the genetic structure of cocoa and new more powerful methods of characterizing, classifying and selecting material. Use of quantitative trait loci has been demonstrated for disease resistance and other traits and could be used to improve the efficiency of selection. In the future, insertion of genes will be possible. There is recognition that biotechnology is a set of tools which is complementary to competent conventional breeding programmes and is best applied to problems which are not easily solved by conventional means. It is important that the biotechnologies should not detract from practical breeding.

9. The analysis of genetic diversity by DNA markers demonstrates large genetic distance between Criollo and Forestero genotypes. There is also significant differentiation among Forastero genotypes. This methodology seems to now be sufficiently advanced to analyze genetic diversity within these groups in germplasm collections. Genetic knowledge generated by these markers could help the choice of base populations for recurrent selection.

10. Effective cooperation in the utilization of cocoa genetic resources depends on the correct identification of individual genotypes. High priority should be attached to development of simple, rapid methods for recognizing mis-identifications. Positive identification of individual clones is a separate problem.

11. INGENIC's first Workshop and the 1992 Workshop in Trinidad have demonstrated the value of meetings among specialists in the genetic improvement of cocoa and the need for an Association. Such workshops encourage the sharing of information and development of new ideas on which future progress depends. With limited resources for cocoa breeding and rising costs, international cooperation is to be encouraged. Genetic resources and their utilization are a common basis for this.

12. Evaluation of genetic resources is a major opportunity for international cooperation. Our conclusion that phenotypic evaluations of economically important traits are useful in parental selection prompts consideration of a multilocational clone trial with diverse germplasm. Such a trial would support development of the required standard methodologies for clone characterization, including for physiological traits, resistance testing, quality evaluation, etc. Early steps in the establishment of such a trial are identification of a core sample of the many clones which are available and improvement and adoption of a rapid, reliable quarantine procedure which can handle large numbers of clones.

13. In the light of the present insecure funding for cocoa germplasm conservation and for practical cocoa breeding programmes, there is a pressing need for stable secure long-term funding. The Workshop participants, therefore, strongly recommend that decision makers should transfer a significant proportion of the monies returned from liquidation of the ICCO Buffer Stock to a fund dedicated to assuring the long-term viability of the world cocoa industry, more specifically to co-ordinated international efforts on cocoa genetic resources.

• These were agreed during the course of this Workshop in Kuala Lumpur held 18-19 October, 1994

APPENDIX VII: Summary of replies received to the questionnaire sent to 20 cocoa producing countries in November 1995

Replies to the inquiry related to the project proposal on *"Cacao Germplasm Conservation and Utilization"*

Question:

Part A: Please estimate priorities given in your country to the following activities (based on importance for cacao improvement).
Priority (1=high, 3=medium, 5=low)

A1 Conservation of:
- internationally available germplasm
- locally available germplasm
- collecting germplasm

A2 Characterization of germplasm by:
- taxonomic/morphologic markers
- isozyme markers
- molecular markers (RAPD, RFLP)
- other:. . . . .

A3 Evaluation of germplasm for:
- agronomic traits (yield, vigour, pod value,...)
- quality traits (butter content, flavour)
- physiologic traits (growth habit, ...)
- resistance to diseases
- resistance to insects
- other: . . . .

A4 Identification of an international "core" collection in cacao germplasm based on:
- geographic/genetic representation
- agronomic value (yield, vigour)
- disease/pest resistance
- other: . . . .

A5 Distribution of a "core" collection to all cacao producing countries:

A6 Establishment of international variety trials is useful for:
- estimation of stability of economically important traits
- comparing internationally available germplasm, not yet present in the country, with local standard varieties
- comparing clones with hybrids
- increasing genetic knowledge (heritability, parent-offspring relationship, heterosis,...)
- other: . . . .

A7 For realization of international trials, preference should be given to:
- hybrid trials
- clonal trials
- both (using clones as the parents of the hybrid trial)

A8 Perform "pre-breeding" activities (=intercrossing valuable genotypes and selecting in progenies), aiming at accumulation of favourable alleles in breeding populations:
- using germplasm available in international genebanks (selected individuals should be distributed)
- using locally available germplasm

A9 Such pre-breeding activities should aim at:
- yield, precocity, pod value, ...
- disease resistance
- pest resistance
- quality
- others: . . . .

Replies Part A:

Organization	A1	A2	A3	A4	A5	A6	A7	A8	A9
CRI Accra Ghana	1 1 3	1 3 1 -	1 3 3 1 3 -	1 1 1 -	-	1 3 5 1 -	1 3 1	1 1	1 1 3 3 -
I R.A Yaounde Cameroon	3 1 5	1 5 5 5	1 4 2 1 1 5	1 1 1 5	1	3 3 3 2 1*	1 1 1	1 5	5 1 1 3 2*
CRIN Ibidan Nigeria	3 1 5	1 1 3 3*	5 5 5 5 5 3*	3 1 1 -	5	3 1 5 3 -	- - 1	1 1	1 1 1 1
IDEFOR Abidjan Ivory Coast	1 3 3	5 3 1 -	1 1 5 1 1 -	1 1 1 -	1	3 3 3 1 -	1 3 3	3 1	3 1 1 1 -
CPCRI Kerala India	1 3 1	1 5 1 -	1 1 3 5 5 -	5 1 5 -	-	5 1 1 5 -	3 1 -	5 1	1 5 5 1 -
B A L Sabah Malaysia	3 4 na	5 na na none	5 5 5 3 2 -	5 0 0 -	5	5 2 4 4 -	- - 5	irevlnt back step	irvlnt " " " "
M C I Sabah Malaysia	1 1 1	1 3 3 -	1 1 1 1 2 -	1 1 1 -	1	3 2 4 1 -	1 1 1	1 1	1 1 2 1 -
ICCRI Jember Indonesia	5 5 1	1 5 3 -	1 1 5 1 1 3*	5 1 1 1*	3	1 3 5 1 -	5 1 3	1 3	1 3 1 1 3*

Organization	A1	A2	A3	A4	A5	A6	A7	A8	A9
PNG Research Rabaul, PNG	3 2 2	3 5 5 -	1 3 2 1 4 -	3 1 1 -	-	4 2 2 3 -	- - ✓	✓ ✓	1 2 3 3 -
Univ. Philippines Laguna Philippines	1 1 1	1 1 1 -	1 1 3 1 1 -	3 1 1 -	1	1 1 1 1 -	1 1 1	1 1	1 1 1 1 1*
Ministry Ag. (CRU) Trinidad	5 2 4	5 5 5 -	1 1 3 1 4 -*	4 1 1 1 *	3	1 2 3 1 -	3 1 5	2 5	1 1 3 1 1*
CIRAD Vanuatu	1 1 3	1 5 5 -	1 1 3 3 3 -	3 1 1 -	3	3 1 1 3 -	1 1 1	1 1	1 1 3 1 -
Koronivia Res. Stn. Nausori Fiji	3 3 3	1 5 3 -	1 3 - 1 3 *	3 3 1 3*	3*	3 1 1 1 -	- - 1	1 1	1 1 3 3 -
INIFAP Chiapas Mexico	1 1 1	1 5 1 -	1 1 3 1 3 -	1 1 1 -	-	1 1 1 1 -	3 1 1	1 3	1 1 1 1 -
CEPLAC Bahia Brazil	1 1 1	3 1 1 -	1 1 1 1 5 -	1 1 1 -	-	1 1 3 1 -	- - 1	1 3	1 1 5 1 -
FHIA St. Pedro Honduras	3 1 1 1 5 3	3 1 5 3 5 5 - -	1 1 1 1 3 3 1 1 5 5 1 1	- 3 5 1 5 1 5 1	- -	3 3 1 1 1 1 3 3 - -	1 1 1 1 1 1	5 1 3 1	1 1 1 1 5 3 1 1 1 1

Organization	A1	A2	A3	A4	A5	A6	A7	A8	A9
INTA Managua Nicaragua	1 3 5	1 5 5 -	1 3 5 1 5 -	1 1 1 -	1	1 1 1 1 -	- - 1	1 3	1 1 3 1 -
INIAP Quevedo Ecuador	1 1 1	3 1 1 -	1 1 3 1 5 -	1 1 1 -	-	1 3 3 1 -	1 1 1	3 1	1 1 5 1 -

* see notation on original questionnaire

Question: Part B: Please indicate the areas in which your institute would be interested in participating actively. Please note that germplasm conservation activities in the project will have to rely largely on counterpart contributions and/or co-financing.

Replies Part B:

B1) Germplasm Conservation - please indicate: a) total number of accessions maintained b) total number of accessions being maintained c) extent of accessions of primary* germplasm already characterized	B2) Primary germplasm characterization. - if yes, indicate for which descriptors:	B3) Primary germplasm evaluation - if yes, indicate which traits:	B4) Reception of clones from an international "core-collection" for inclusion in your local collection:	B5) Participation in an international hybrid trial (land req. ± 2.5 ha)	B6) Participation in an international clonal trial (land req. ± 2.5 ha)	B7) Participation in internationally coordinated pre-breeding activities - if yes, please indicate how	B8) Reception of seed or clones from improved populations created elsewhere
CRI, Ghana: a) - - Yes b) 740	Yes. Passport management, characterization and evaluation	Yes. 1) Resistance to CSSV. 2) Resistance to *P. Megakarya* , *P. palmivora*. 3) Yield and yield pattern	Yes	Yes	Yes	Yes	Yes
ITA Yaounde: a) 210 - Yes b) 180	No	Yes vigor, yield, diseases resistance	Yes	Yes	Yes	No	Yes
CRIN, Nigeria a) ± 1,500 - yes b) ± 750 - yes c) <50 - yes	Yes, Morphological	Yes Yield, precocity, resistance, quality	Yes	Yes	Yes	Yes Evaluation of the materials being proposed	Yes
IDEFOR, Ivory Coast a) 700 - Yes b) 700 c) 50	Yes, number of ovules/ovary,pod weight,pod diameter, seed weight, seed size etc.	Yes. Resistance to mirids, to phytophthora quality, yield.	Yes	Yes	Yes	Exchange material and communicate result of trials	Yes
CPCRI, India	Yes. Yield, vigour, pod value,	No	Yes	Yes	Yes	No	Yes

B1) Germplasm Conservation - please indicate: a) total number of accessions maintained b) total number of accessions being maintained c) extent of accessions of primary* germplasm already characterized	B2) Primary germplasm characterization. - if yes, indicate for which descriptors:	B3) Primary germplasm evaluation - if yes, indicate which traits:	B4) Reception of clones from an international "core-collection" for inclusion in your local collection:	B5) Participation in an international hybrid trial (land req. ± 2.5 ha)	B6) Participation in an international clonal trial (land req. ± 2.5 ha)	B7) Participation in internationally coordinated pre-breeding activities - if yes, please indicate how	B8) Reception of seed or clones from improved populations created elsewhere
a) 95 b) 95 c) NIL	butter content, flavour and drought tolerance						
BAL, Malaysia a) 230 b) 230 c) Done as trees crop	Or evaluation? Yes. Bean ??? Beans per pod Compatibility	Yes Yield, growth habit.	Possibly	Possibly	Possibly	No	No interest
M C B, Malaysia a) 1,000 - yes b) 800 c) 20%	Morphological descriptors on pod, beans and flowers	Yes, yield,butter content, bean quality and VSD tolerance	Yes	Yes	Yes	Yes	Yes
ICCRI, Indonesia a) 256 b) 62 c) -	Yes Agronomic characteristics	Yes, Yield and bean characteristics	Yes	Yes	Yes	Yes	Yes
PNG CCRI, PNG a) - No b) - c) -	No	No	Yes	Yes	Yes	Yes	Yes
Uni. Philippines Laguna. a) Less than 30. Yes	Yes. Morphological, biochemical	Yes. Yield, quality, resistant to pests/diseases	Yes	Yes	Yes	Yes. Collection, establishment of base populations (both intl. & locally available criollo pops.)	Yes
Ministry of Agriculture Trinidad & Tobago a) 865 - yes\	No	No	Yes	Yes	Yes	Yes. Production of hybrids and evaluation	Yes

B1) Germplasm Conservation - please indicate: a) total number of accessions maintained b) total number of accessions being maintained c) extent of accessions of primary* germplasm already characterized	B2) Primary germplasm characterization. - if yes, indicate for which descriptors:	B3) Primary germplasm evaluation - if yes, indicate which traits:	B4) Reception of clones from an international "core-collection" for inclusion in your local collection:	B5) Participation in an international hybrid trial (land req. ± 2.5 ha)	B6) Participation in an international clonal trial (land req. ± 2.5 ha)	B7) Participation in internationally coordinated pre-breeding activities - if yes, please indicate how	B8) Reception of seed or clones from improved populations created elsewhere
CIRAD, Vanuatu a) 100 - Yes b) 60 c) 25	-	Yes number of flowers, flustres, yield, pods characteristic and bean quality. Relationship with climatic condition.	Yes Presently from Reading and Montpellier (CIRAD)	Yes	Yes	No	Yes Presently from Ivory Coast and Malaysia
KRS, Fiji a) 115 b) 35 c) -	Yes. Taxon/morph. molecular	Yes diseases, bean yield, quality	Yes	Yes	No	No	Yes
INIFAP, Mexico a) 175-Yes b) 175 c) -	Yes. Botanical descriptors of pod, bean, flower, compatibility & phytophthora reaction	Yes Resistant clones to phytophthora, moniliasis and witches broom, diseases.	Yes	Yes	Yes	Yes Choice of parents. Crossing among clones	Yes
CEPLAC, Brazil a) 1,000 b) 1,000 c) 180	Yes Fruits, leaves and flowers	Yes. (about 450 access) Yield, field resistance (black pod and witches broom), pod and seed characteristics, quality.	Yes	Yes	Yes	No	Yes
FHIA, Honduras a) 180 - Yes b) 180 c) 86 from CATIE and others	Yes IF we get breeder. No	Yes Yield, vigour, pod value, resistance to disease, resistance to insects, production in rustic conditions	Yes	Yes	Yes	Yes IF we get breeder. No	Yes

B1) Germplasm Conservation - please indicate: a) total number of accessions maintained b) total number of accessions being maintained c) extent of accessions of primary* germplasm already characterized	B2) Primary germplasm characterization. - if yes, indicate for which descriptors:	B3) Primary germplasm evaluation - if yes, indicate which traits:	B4) Reception of clones from an international "core-collection" for inclusion in your local collection:	B5) Participation in an international hybrid trial (land req. ± 2.5 ha)	B6) Participation in an international clonal trial (land req. ± 2.5 ha)	B7) Participation in internationally coordinated pre-breeding activities - if yes, please indicate how	B8) Reception of seed or clones from improved populations created elsewhere
INTA, Nicaragua a) - b) 200 c) -	-	-	Yes	Yes	Yes	Yes. Evaluation of the best individuals from hybrid trials in clonal plantations	Yes
INIAP, Ecuador a) 900 - Yes b) 400 c) 60	Yes - Flower, pod, leaves,seeds	Yes - quality, resistance, yield	Yes	Yes	Yes	Recollect germplasm, (illegible)	Yes

* Primary germplasm is defined as wild or remnant material of cultivation in your genebank and NOT bred material.

Question:

Part C: The project document proposes the establishment of multilocational trials (i.e. clonal and hybrid) in different producing countries (8-10 sites). The choice of countries will be based on the commitment of countries as well as the representativeness of the sites. The costs involved, as would be covered by the project, are estimated at US$2,000 per ha per year. Please note that the project can only pay for establishment and maintenance costs (no salaries) and the supplemental costs involved in data recording.

Please indicate if this cost estimate is realistic:
- **YES**
- **NO, maintenance costs are estimated to be US$ . . . . ha/year**

Replies Part C:

CRI, Ghana		NO - $3,000
IRA, Yaounde		NO - $6,000
CRIN, Nigeria	YES	
IDEFOR, Ivory Coast	YES	-
CPCRI, India	YES	
BAL, Malaysia	YES	
MCB, Malaysia		NO - US$ 1,000
ICCRI, Indonesia	YES	
CCRI, PNG		NO - $2,500
Uni. Philippines, Laguna		NO - $3,000
Ministry of Agric., Trinidad & Tobago	YES (staff & land)	-
CIRAD, Vanuatu	YES	
KRS, Fiji	YES	
INIFAP, Mexico	YES	
CEPLAC, Brazil	YES	
FHIA, Honduras*	-	-
INTA, Nicaragua	YES	
INIAP, Ecuador	YES	

* It was not clear to us exactly what costs were to be included in the $2,000/ha proposed. Our basic costs for maintaining a hectare of low-input cacao come to about $700.00 not including the labor intensive activity of data-taking. Were we to manage our cacao more intensively with chemical fertilizers and pesticides, our costs would increase substantially. Our main costs are in human resources and that is probably where we would need the most assistance. Are you referring to senior staff salaries, to field worker salaries or to both?

Question:
Part D: The project proposes to initiate pre-breeding activities at 3-4 sites, the results of which should be made internationally available. It is proposed to include international germplasm centres as bases for such activities, and possibly one or two producing countries that are willing to participate in this activity. The costs for this activity will (partly) covered from the project. Please give your opinion on this suggestion:

Replies **Part D:**

CRI, Ghana	The approach is laudable and Ghana is willing to be one of the participating producing countries.
IRA, Yaounde	Producing countries should be encouraged to participate in pre-breeding activities. Scientists from these countries could be trained in International Germplasm Centres in order to perform such activities in producing areas for sustainable results.
CRIN, Nigeria	Cocoa Research Institute is all out for these activities. All provisions proposed are agreeable, also the conditions attached to them.
IDEFOR, Ivory Coast	Prebreeding activities should be conducted in producing countries as well as in international germplasm centres. Moreover, evaluation using a simple molecular technique like RAPD should be extended to national breeding centers.
CPCRI, India	Initiating pre-breeding activities at selected sites and making available the results to other countries are very useful proposals since these will avoid the need to undertake such activities in each cocoa producing country and thereby save cost input and other resources.
BAL, Malaysia	Not considered useful - see main response.
MCB, Malaysia	Good and funds should be made available for it.
ICCRI, Indonesia	ICCRI will support and take part in the activities, especially in providing research necessities. We suggest one of the activities to be based in a country of Asia and the Pacific region.
CCRI, Papua New Guinea	The idea of pre-breeding activities at 3-4 sites is a very good one provided it will be done properly with well defined objectives. Long term realistic funds might be essential.
Uni. Philippines, Laguna	I support this idea. I also propose that other countries or sites should be included especially if they have a need. Example of countries may be included are those producing countries which have grinding capabilities.
Min. Agriculture Trinidad & Tobago	Pre-breeding activities are necessary for accumulation of desirable genes to be included in the breeding programme of Trinidad and Tobago. Technology for pre-breeding exercises is available.
CIRAD, Vanuatu	OK but it should be very important to consider the local characteristics (for example: Pacific Region).

	Small countries in Pacific region have not necessary structures or people available to do important studies. However, cocoa development projects in those countries have to be considered as priorities.
KRS, Fiji	We are in support of Part D. proposals.
INIFAP, Mexico	I agree with this proposal.
CEPLAC, Brazil	CEPLAC agrees with this proposal.
FHIA, Honduras	This proposal appeals to us and we would be willing to participate as one of the few remaining (or the only) cacao research center left in Central America. Because cacao is native to the Americas we strongly feel that one of the pre-breeding sites should be in this region. Our limitation, as mentioned throughout this response, is that we do not have the financial base to acquire long-term human resources to do the work outlined.
INTA, Nicaragua	In the case of breeding for resistance to pest or diseases, the pre-breeding activities have to be realized in countries where these limitations do exist. Example: Nicaragua - pre-breeding for resistance to Monilia.
IIAP, Ecuador	Considering that the Amazon Region is the centre of origin of cacao and that Ecuador is the leading producer of aromatic cacao in the world, it is suggested to be one of the bases for this activity. The other country could be Trinidad or Brazil.

Question:
Part E: Please give any general comments regarding the proposed project activities.

***Replies* Part E:**

CRI, Ghana	The involvement of producer countries is limited. Support of more hybrid trials in producer countries will greatly help such countries.
IRA, Yaounde	Well planned project. However: - underestimated costs to be re-adjusted, - training activities to be highlighted.
CRIN, Nigeria	The overall idea is a laudable one that will foster lasting linkage between all cocoa based institutes.
IDEFOR, Ivory Coast	The project is good, however, some institutions are involved in all activities. It would be interesting to better share activities, with regard to the scientific capacity but also to the availability of a good research program. This type of project should be intended to help maintain a good scientific level to all participants.
CPRI, India	The proposal to organize international collaboration in cocoa germplasm conservation evaluation and utilization in breeding programme is a step in the right direction. This will not only help in exchange of cocoa germplasm, but also make available the results to all interested countries for effective exploitation of valuable breeding materials for increasing the production and productivity. Probably at a later stage this project can be developed to Cocoa Genetic Resources Network with the patronage of IPGRI.
BAL, Malaysia	See main response (cover letter).
MCB, Malaysia	The project is sound and a good approach. However, a lot of coordination and logistics are required. Simultaneous implementation of the joint project may be difficult.
ICCRI, Indonesia	The project should involve the activities of breeding for less favourable conditions (toxicity, drought tolerance, etc.).
CCRI, Papua New Guinea	The proposed project activities are particularly oriented to benefit breeding programmes and therefore are very welcome.
Uni. Philippines, Laguna	This program should be pursued as soon as possible. I would like to add, as a component of the program, the collection of available criollo population which is a source of genes for quality improvement. In the Philippines, this is an important concern.
Min. Agriculture Trinidad & Tobago	The outcome of these activities should enhance **cocoa production in terms of field**, disease and pest resistance an flavour maintenance over time.
CIRAD, Vanuatu	None.
KRS, Fiji'	The proposed project activities are generally acceptable. High priority should be given to evaluation of germplasm to *Phytophthora* diseases screening. We would also suggest that evaluation should include the suitability of the germplasm to inter-cropping systems.

INIFAP, Mexico	The project does not include cocoa propagation. I consider it necessary to investigate on cocoa propagation by *in vitro* culture. The recent results on microcutting (Flynn *et al* 1990) and on somatic embryogenesis from maternal tissue (Lopez *et al* 1993) indicated that *in vitro* cocoa propagation is possible; however for a practical application it would be necessary to improve it. The perfecting of *in vitro* propagation could be an important tool for *in vitro* germplasm conservation and the safe international movement of material.
CEPLAC, Brazil	It should be important to discuss the participation of the national local collections in the project.
FHIA, Honduras	We would like to participate in the proposed project activities to the extent that we can with our limited financial and human resources. As a research institute we do have land and infrastructure and we do have a history of plant breeding and germplasm management, but in other crops, i.e. banana, plantain (in cooperation with INIBAP) and soybean. We would expect some synergies between this project and our main work which is the transfer of technology, vegetative materials, and research in agronomics, to the cacao producers of Honduras (and now to Central America with the reduced role that CATIE is playing in those areas). We would like to suggest that someone from your staff comes to visit FHIA and its cacao program before the final decisions are made on who will participate in this project
INTA, Nicaragua	Our Institute is very interested in this kind of project. Even if Nicaragua is not an important cocoa producer for the world market, many of our farmers in the humid tropics depend on this crop and several national projects are contributing to expand the cocoa culture as an alternative three crop system for the rain forest regrow(?). In the past we had already a regional collaboration with CATIE and FAO in the establishment of our cocoa collection but until today the evaluation of this germplasm remains an isolated effort. We hope to find some active participation
INIAP, Ecuador	In Ecuador the total renewal of the national cacao germplasm collection and of other genetic groups has been proposed, to facilitate handling and evaluation.

APPENDIX VIII: Summary of replies received from the Part II information request sent in April 1996.

Replies information request - **PART II**
"Cocoa Germplasm Conservation and Utilization"

Question

A. General information

1) Area in hectares presently occupied with cocoa breeding trials (clones, hybrids): ________

2) Additional land available at station for project trials of cocoa (in ha.): ________

3) Human resources available to support project activities (number of persons):
   - breeders: ________
   - agronomists: ________
   - technicians: ________
   - labourers: ________
   - others (please specify): ________

4) Laboratory facilities exist for:
   - quality testing: yes/no
   - simple disease resistance testing: yes/no

5) Nursery facilities: yes/no

6) Skilled staff for
   - grafting: yes/no, method(s): ________
   - rooting of cuttings: yes/no

7) In the past, for clonal material received from Reading or Montpellier quarantine centres, were entry quarantine measures mandatory in your country: yes/no

Replies Question A:

Organization	1)	2)	3)	4)	5)	6)	7)
CRIN Nigeria	72.24ha	250ha	Breeders=5, Agron=1, Tech.=4 lab, 10 field; Labourers=650; Clerks,typists	QT= yes SDRT = yes	yes	yes, patch, budding yes	yes
VARTC-CIRAD, Vanuatu	14ha	over 15ha.	Breeders=2 Agron=2 Tech=4 Labourers=25 Casual workers for harvesting & cleaning	QT=no, but we can make simple tests SDRP=Yes	yes	yes, chip budding no	no
CRU, Trinidad	5ha.	50ha.	Breeders=1 Agron=1 Tech.=2 Labourers=10	QT= yes SDRT = yes	yes	yes, wedge & side yes	yes
CPCRI, India	11.5ha	20ha	Breeders=2 Agron=1 Tech=2 Labourers=7	QT=yes SDRT=yes	yes	Yes, soft- wood grafting no	yes
MCB, Malaysia	30ha	500ha	Breeders=2 Agron=1 Tech=2 Labourers=6 or more as required	QT=yes SDRT=yes	yes	yes, bud grafting no	yes
IDEFOR-DCC, Ivory Coast	23ha	over 1,000ha	Breeders=1 Agron=1 Tech=4 Labourers=8	QT=yes SDRT=yes	yes	yes, 2 methods yes	no
CATIE, Costa Rica	5ha	20-30ha	Breeders=1/2 Agron=1/2	- SDRT=yes	yes	(1/2 grafter) bud grafting	-

			Tech=1 Labourers=1-2 Other: Lab/library/computer center			no	
CCRI, P. New Guinea	100ha	100ha	Breeders=3 Agron=3 Tech=8 Labourers=15	QT=yes SDRT=yes	yes	yes yes	yes
FHIA, Honduras	3ha	10ha	Breeders=0 Agron=2 Tech=1 Labourers=5	QT=yes SDRT=yes	yes	yes, patch budding no	-
INTA, Nicaragua	10ha	10ha	Breeders=1 Agron=1 Tech=1 Labourers=6 temp if necessary Other=secy 1	QT=yes,lab Managua SDRT=yes	yes	yes=graft (U and reverse) yes,prefer grafting because of wind susceptibility	Only introduced clonal marterial from CATIE.Will advise further re material from Reading or Montpellier.
INIAP, Ecuador	5ha	9ha	Breeders=2 Agron=6 Tech=2 Labourers=0	QT=no SDRT=yes	yes	yes=patch yes	yes
ICCRI, Indonesia	12ha	6ha	Breeders=6 Agron=7 Tech=4 Labourers=2 Others=2 ?	QT=yes SDRT=yes	yes	yes, budding, side-grafting yes	yes
CRI, Ghana	50hA	30HA	Breeders=4 Agron=5 Tech=6 Labourers=25	QT=yes SDRT=yes	yes	yes	yes

			:				
CEPLAC/CEPEC, Brazil	65ha	150ha	Breeders=6 Agron=- Tech=8 Labourers=70 Others=2 Sec'y	QT=yes SDRT=yes	yes	yes, budding & side graft no	yes
INIFAP, Mexico	8ha	50ha	Breeders=1 Agron =- Tech=3 Labourers=8 -	QT=no SDRT=yes	yes	grafting yes micrografting yes	yes

Question

B. Is your institute still interested in participating in the:

- international clone trial: yes/no
- international hybrid trial: yes/no
- population breeding activities: yes/no
-

***Replies* Question B:**

Organization	Int'l clone trial: YES or NO	Int'l hybrid trial: YES or NO	Population breeding YES or NO
CRIN, Nigeria	yes	yes	yes
VARTC-CIRAD, Vanuatu	yes	yes	yes
CRU, Trinidad	yes	yes	yes
CPCRI, India	yes	yes	yes
MCB, Malaysia	yes	yes	yes
IDEFOR-DCC, Ivory Coast	yes	yes	yes
CATIE, Costa Rica	yes	yes	yes
CCRI, Papua New Guinea	yes	yes	yes
FHIA, Honduras	yes	yes	yes
INTA, Nicaragua	yes	yes	no
INIAP, Ecuador	yes	yes	yes
ICCRI, Indonesia	yes	yes	yes
CRI, Ghana	yes	yes	yes
CEPLAC/CEPEC, Brazil	no	no	yes
INIFAP, Mexico	yes	yes	yes

NOTE 6 June, 1996: **Koronivia Researc Station, Fiji** advised they cannot be fully involved, owing to limited resources but they can still participate by **testing a few of the best clones** arising out of the selections.

Question B (contd.) Please indicate any constraint(s) you might foresee which could restrict your involvement in these trails:
Replies Question B

Organization	Constraints which might restrict involvement in these trials
CRIN, Nigeria	1) Unpredictable environmental factors, e.g. season 2) Plant quarantine bottlenecks
VARTC-CRIN	* Environmental constraint: cyclone period (January to April). Damage can be limited by use of wind breaks. * No disease constraints very important: Rose beetle and black pod disease are the two main problems. We can control these pests.
CRU, Trinidad	Choice of clones and parents for hybrid trials. Clones must meet the approval of the Ministry of Agriculture with respect to flavour and pest/disease characteristics.
CPCRI, India	Permission of the Director General, Indian Council of Agricultural Research, Krishi Bhavan, New Delhi 110 001, India (Fax: 91 11 338 7293) is a prerequisite.
MCB, Malaysia	Funding - depending on the government allocation for cocoa research.
IDEFOR-DCC, Ivory Coast	-
CATIE, Costa Rica	Budget and time.
CCRI, P New Guinea	nil
FHIA, Honduras	The absence of a cocoa breeder in our programme
INTA, Nicaragua	None
INIAP, Ecuador	-
ICCRI, Indonesia	-
CRI, Ghana	Page missing
CEPLAC/CEPEC, Brazil	We have specific interest in the search of resistance to witches' broom disease. Our breeding programme is basically directed to the development of resistant varieties combining two or more sources of resistance.
INIFAP, Mexico	-

Question

C. Counterpart contribution

As required by the CFC the detailed counterpart contributions for each of the activities have to be listed in the proposal. Therefore, kindly estimate the expected amount of counterpart contributions, (i.e. fixed costs per year which your institute is expected to make in order to participate in the following activities, if applicable):

- clonal trial (2.5ha): _________$/year
- hybrid trial (2.5ha): _________$/year
- population breeding activities: _________$/year

It would also be appreciated if you could indicate the expenditures your institute/country is making for the **conservation** of cocoa germplasm as well as for **characterization** efforts.

- conservation: _________$/year
- characterization: _________$/year

***Replies* Question C**

Organization	Clonal trial $/year (2.5ha)	Hybrid trial $/year (2.5ha)	Population breeding $/year	Conserv-ation $/year	Character ization $/year	Additional comments
CRIN, Nigeria	2,000	2,500	1,500	1,500	3,000	none
VARTC-CIRAD, Vanuatu	2,500	2,000	4,000	2,000	3,500	* The costs, as indicated above are including land preparation and general works fo rmaintenance based on the Vanuatu conditions. * For the quality tests, normally we send our samples to CIRAD Montpellier for analysis and comments. All chemical analysis and flabour tests are made by technicians (E CROS Laboratory)
CRU, Trinidad	5,000*	5,000	5,000	-	-	* This cost represents the labour component fo the three activities.
CPCRI, India	5,000	5,000	6,000	8,000	3,000	-
MCB,Malaysia	5,000	5,000	10,000	12,000	8,000	-
IDEFOR-DCC, Ivory Coast	7,000	7,000	7,000	3,000	-	-

CATIE, Costa Rica	0	0	0	15,000	5,000	The Unit of Biodiversity of Genetic Resources have initiated (Jan. '96) with the characterization of cacao germplasm. CATIE has 700 clones of cacao and only 250 of them have been characterized.
CCRI, PNG	10,000	10,000	?	10,000	5,0000	The 1996 cocoa breeding budget of the CCRI is about US$300,000 much of which is "population breeding". In addition, a large budget is allocated to cocoa pathology whcih has a major emphasis on disease (phytophthera) resistance. Cocoa quality Section of the Institute analyzes about 1,000 clones per year for quality characteristics for the cocoa Breeding Section. The Institute is currently building two large research stations in E. New Britain and Madang.
FHIA, Honduras	1,250	1,250	1,500	5,000	5,000	-
INTA, Nicaragua	4,338	4,338	-	4,000	2,500	I agree with you about all aspects.
INIAP, Ecuador	2,000	2,000	3,000	3,000	1,500	-
ICCRI, Indonesia	5,000	4,000	5,000	5,000	5,000	-
CRI, Ghana	page missing					
CEPLAC/CEPEC, Brazil	-	1,500	1,500	10,000	2,000	-
INIFAP, Mexico	3,000	3,000	4,000	2,000	5,000	-

Question

Part D. Please make additional comments on any of the project activities and/or suggestions above:

No replies were received.