GRO-Cocoa

Issue 14
December
2008

Global Research On Cocoa - *working with and for farmers*

New Blood

This issue covers discoveries and ventures that could improve cocoa productivity. We begin with a study redrawing the cocoa tree, dividing Forastero into seven new groups or 'clusters'. It has long been known that cocoa in the Amazon basin contained as-yet untapped cocoa diversity, but this study has delimited different foci of diversity, information that can help improve management and exploitation of germplasm for breeding.

Next we have a report on Nigeria's programme to rejuvenate its cocoa industry; a multi-institutional initiative is helping farmers rehabilitate cocoa on their farms, while the farmers have participated in identifying important constraints to this. We follow this with a report on a new CATIE-led project. As cocoa farming, poverty reduction and conservation are closely linked in Central America, the project is working with cocoa farmer organisations in six countries to improve competitivity of cocoa production and environmental services.

The causal agent of witches' broom received a new name not long ago (*Moniliophthora perniciosa*), and we highlight a recent review summarising what else is new with this long-standing cocoa scourge and efforts to combat it, identifying also where research is most needed. We include a note on an excellent farmer training manual for Papua New Guinea, which is useful practically for farmers and could inspire production of similar aids elsewhere.

There is news on COPAL's International Cocoa Research Conference in Indonesia. We start, though, with a clarification about use of metalaxyl on cocoa destined for the European Union.

Update on Metalaxyl Use

In relation to the article entitled 'New EU pesticide regulations and West Africa' published in *GRO-Cocoa* No. 13 (June 2008), ECA/CAOBISCO have provided supplementary information to the Box on p. 7 – the list of active substances used on cocoa but not approved for use in the European Union (EU) – to indicate that approval for use of metalaxyl (unresolved) in the EU has been extended to June 2010, when a final decision on its authorisation status will have to be made.

Criollo cocoa from Matagalpa, Nicaragua; the mystery of its origins is just one puzzle unravelled in a study that gives new insights for breeding cocoa and managing germplasm (Tito Jiménez Chacón)

Cocoa Family Tree Revised

The authors of a study published in the online journal *PLoS ONE*[1] propose a new 'cocoa tree' with many more branches than before. They say it should enhance management of cocoa (*Theobroma cacao*) germplasm, and it also sheds new light on some of the mysteries surrounding the cocoa grown around the world today.

Many expeditions to collect cocoa germplasm have been undertaken in Latin America over the past century. However, most of this germplasm has not contributed to cocoa improvement because its relationship to cultivated selections has been poorly understood. In addition, germplasm labelling errors have hampered breeding and confounded the interpretation of diversity analyses.

Until now, cultivated cocoa has been classified, based mainly on pod/bean characters and cocoa taste, into two main groups: Criollo (fine cocoa) and Forastero (bulk cocoa); and three smaller subgroups: Amelonado (a Forastero grown in Brazil, and the earliest cocoa taken to West Africa), Nacional (grown in Ecuador) and Trinitario (Amelonado–Criollo hybrids grown in Trinidad). Authors have often disagreed on their origins and how they are related.

In the new study, 1241 individual cocoa plants from different geographical origins were genotyped using 106 microsatellite markers. Plants came from collections of seed or budwood made in 1930–2005 in primary forests, or from cultivated materials, and originated from 12 countries in South and Central America. Much of the wild material came from Peru (44% of clones), *T. cacao*'s putative centre of origin, with Brazil supplying 26% and Ecuador 18% (but these included cultivated clones

In This Issue

dragonprints

belonging to traditional cultivars classified as Criollo, Amelonado and Nacional). Also included, to study relatedness with wild clones, were Criollo from Central America, 'true' West African Amelonado from Ghana, a Matina clone from Costa Rica, several Común clones from Brazil, and Nacional clones from Ecuador's Pacific coast. Some Amelonado selections (e.g. from Brazil) were included, but Trinitario and Trinitario × Amazonians clones (i.e. hybrids between Criollo and Amelonado, and Trinitario and Amazon basin wild cocoa) were excluded.

A computer program, Structure, was used to perform Bayesian cluster analysis; i.e. to put plants into probable groups in terms of genetic similarity on the basis of the microsatellite markers they share. But given the degree of inaccurate 'passport' (labelling) data in cocoa germplasm collections, the first task was to identify and exclude mislabelled clones. Once this had been done, the remaining 952 plants were analysed. The program places each plant in one or more of a number of clusters, and assigns a probability (the coefficient of membership) of it belonging in each. Since there is no clue at the outset as to how many clusters there should be, the total number is changed sequentially as the program is run again and again until a 'best fit' is reached for number of clusters and the plants that belong to each.

So, ten geographically based genetic clusters were identified that represented highly differentiated populations, and the authors named these by either traditional cultivar name, or geographic location where no traditional name applied:

- Amelonado
- Criollo
- Nacional
- Contamana
- Curaray
- Guiana
- Iquitos
- Marañon
- Nanay
- Purús

Amelonado, Criollo and Nacional were confirmed as distinct clusters, but the analysis revealed seven other highly differentiated populations in what has until now been classified together as Forastero. The highest genetic diversity was found in the Upper Amazon, supporting the view that this is the likely centre of origin of *T. cacao*. Individuals in the Nanay and Iquitos clusters were collected in small (even overlapping) areas, relative to some other clusters, but possessed genetic traits that made them quite distinct.

Further analysis identified 3–5 subclusters within each cluster, 36 in all, which roughly corresponded to geographical locations or traditional cultivars. The results were similar when a different statistical method was applied, (which measured percentage dissimilarity of genetic material), apart from two clusters: Purús and Iquitos (discussed below).

The results provide insights into some long-standing questions.

- Cocoa in Central America. Criollo and only Criollo was found in Central American primary forests (Mexico and Panama), while all ten clusters including Criollo were found in South American forests. Non-Criollos in Central America were found only on existing farms, indicating they were introduced later than Criollos. The presence of Criollos in what are now forests in Mexico suggest that those areas may have been cultivated in pre-Columbian times. The results do not support the hypothesis that cocoa evolved in Central America separately from its evolution in the Amazon basin.
- Origins of Nacional cocoa. The subclusters provide clues to the origin of Nacional, which has generally been considered as native to Ecuador. Although individuals from the Amazonian side of the Andes were placed in the Nacional cluster group, they were not in the Nacional subcluster – which contained only plants from the Pacific side (Ecuador) – but in a separate (Morona) cluster. This difference probably reflects centuries of human selection of Nacional cocoa on the Ecuadorian Pacific coast.
- Origins of Amelonado cocoa. These remain less clear. Traditionally thought to be part of the Forastero group, wild individuals placed in this cluster came from distant locations, although some were from the Para River in northeastern Brazil from where, historical sources suggest, Amelonado was domesticated.
- Gene flow along the Amazon. The discrepancies found using two methods of analysis regarding subclusters of the Purús and Iquitos clusters may relate to gene flow (the transfer of traits from one population to another). There are indications this has occurred throughout this area, and extensive gene flow throughout the Amazon River makes it difficult to cluster some populations downstream.
- Amazon diversification hypotheses. The results do not support either the riverine or the refuge centres hypotheses of Amazon species diversification. The pattern of differentiation of the cocoa tree populations studied appears to be linked to potential dispersal barriers created by ancient ridges also called palaeoarches. Nevertheless, further collection trips are needed to specifically investigate the association between the palaeoarches and the genetic structure of *T. cacao*.

The overriding importance of these results, however, is the new classification of cocoa germplasm into ten major clusters, or groups. The authors say this reflects more accurately than the traditional classification the genetic diversity now available for breeders. They conclude the paper by encouraging the establishment of new mating schemes based on the high degree of population differentiation they have reported. They also propose that germplasm curators and geneticists should use the new classification scheme in their endeavour to conserve, manage and exploit cocoa genetic resources.

[1]Motamayor, J.C., Lachenaud, P., da Silva e Mota, *et al.* (2008) Geographic and genetic population differentiation of the Amazonian chocolate tree (*Theobroma cacao* L). *PLoS ONE* **3**(10): e3311. doi:10.1371/journal.pone.0003311.

Contact: Philippe Lachenaud, CIRAD
Email: philippe.lachenaud@cirad.fr

Cocoa Rehabilitation in Nigeria

The Central Bank of Nigeria has attributed the slow growth of the Nigerian economy to slow growth in the agricultural sector, which is characterised by rising food imports and inadequate use of improved technology. Agricultural policies, which have witnessed several changes since the colonial and post independence years, have had positive or negative effects on the extension services provided to the cocoa industry in Nigeria. Extension was directed towards cash crops (including cocoa) before oil discovery but later the focus shifted to food crops. The position of Nigeria as second in world cocoa production was lost and currently the country is far behind many other cocoa producing nations. At present, the Federal Government is making efforts to revitalise cocoa production at all levels through various cocoa rehabilitation programmes being implemented by governmental and non-governmental organisations (NGOs).

While average cocoa production was increasing up to 1970–1974 when it reached 239,000 tonnes, after the discovery of oil it fell, and this trend continued until 1985–1989 when average production was 120,000 tonnes (Table 1). From 1990, average cocoa production has increased,

Period	Production (tonnes)
1967–1969	227,660
1970–1974	239,000
1975–1979	203,000
1980–1984	160,000
1985–1989	120,000
1990–1994	146,000
1995–1999	150,400
2000–2004	175,000

Table 1. Nigeria cocoa production trend 1967–2004 (source: statistics from cocoa traders Gill and Duffus and ED&F Man.)

reaching 175,000 tonnes in 2000–2004. This figure is far below the average production before oil was discovered. According to FAO (UN Food and Agriculture Organization) statistics, cocoa acreage actually declined for most of the 1980s, which the ICCO (International Cocoa Organization) said could be attributed to cocoa farm abandonment[1], while an increase in the 1990s could be attributed to the effort of the Federal Government in promoting cocoa production through the National Cocoa Development Committee (NCDC).

The need for rehabilitation of cocoa trees in Nigeria was supported by the ICCO in 1999[1], which pointed out that cocoa plantations were beginning to age in Africa and the rate at which the trees were being regenerated was insufficient. This view was reiterated in Vos & Krauss[2], which reported that most cocoa trees in Nigeria are old and abandoned by cocoa farmers.

A study carried out in five cocoa producing states in Nigeria, namely: Kwara in the North-central zone, Edo and Ondo in the Southwest, Cross River in the Southeast and Taraba in the Northeast, revealed that the mean age of cocoa trees was almost 27 years; Taraba had the highest mean age (34.5 years), while Cross River had the lowest (16.9). Mean cocoa tree ages of 29.6, 25.8 and 23.5 years were recorded for Ondo, Edo and Kwara respectively. The lower mean age of cocoa in Cross River can be attributed to new entrants into cocoa farming in that state.

The age of cocoa trees is one of the factors that determine whether the farm is due for rehabilitation or not. An old tree will definitely lose productivity and need to be rejuvenated/replaced. Other factors include the incidence of pests and diseases. The factor(s) responsible for a decline in yield would suggest the type of rehabilitation that should be employed on a particular farm.

Cocoa Rehabilitation Techniques

Cocoa rehabilitation is the process whereby unproductive cocoa farms can be made productive by extending the economic life of a cocoa plantation by replacing old trees with improved younger cocoa seedlings or using various methods, such as coppicing, to encourage old cocoa trees to become more productive.

The Raw Materials Research and Development Council (RMR&DC)[3], identified causes of decline in the level of cocoa production in Nigeria as the age of trees, a decline in soil fertility, infestation by pests and diseases, use of obsolete/unimproved varieties and inappropriate cultural practices. It recommended corrective processes be adopted for rehabilitation, ranging from replanting to phased replanting using any of a number of tested methods including coppicing, grafting or budding.

A number of authors[4,5,6] have identified the six different types of cocoa rehabilitation techniques (CRTs) described below. CRIN (Cocoa Research Institute of Nigeria)[6] explained the factors that determine type(s) of CRT(s) to be adopted by farmers on cocoa plantations as follows:

- Coppicing or chupon regeneration is carried out by complete removal of the main stem using a chainsaw or cutlasses to cut at 30 cm above ground level at a slightly oblique angle; the cut surface is painted with red paint to prevent termite attack. Three chupons are allowed to re-grow and after a year the most vigorous chupon is retained to develop into a tree by removing the less vigorous chupons. The return of the re-growth into production within two years is of significant advantage but the disadvantage of this technique is that farmers cannot plant new cultivars, which might have higher yield possibilities and other potentially desirable characteristics.
- Phased replanting is recommended if only part of the farm has been identified to be giving low yield, or farmers cannot afford the cost of replanting the entire plantation at once. In the latter case, it is significant that it will be three years before income can be realised from the rehabilitated plots. The farm could be divided into three and the replanting exercise could be spread over three years. If these procedures were followed, the trees planted on the first part of the farm would have started producing by the time the farmer starts re-planting the last one-third of his farm. Thus, the farmer does not experience total loss of production during the period of phased replanting.
- Selective planting or gapping up is recommended if the population acreage has fallen below 80% or if most of the trees have been found to be unproductive for over six years. Gapping up missing trees with seedlings of a high yielding variety, or cutting out unprofitable trees, and then replanting them with improved varieties close to where the unprofitable trees have been removed will rehabilitate such a farm.
- Complete replanting is recommended if the plot is affected by swollen shoot disease, especially in the area of mass infection (AMI), or if the trees have exceeded their productive age. The diseased or old trees should be cut down with a chainsaw or cutlasses as uprooting them with a bulldozer carries the risk of destroying all the organic matter, thereby encouraging leaching of nutrients and damaging the structure of the surface horizons of the soil. After the removal of the old trees, seedlings of improved varieties can be planted to replace them.
- Planting of young cocoa seedlings under old trees is recommended on plots with low yielding varieties or where cocoa trees are too old. The approach allows cocoa seedlings of improved varieties to be planted between old cocoa trees. The old and new trees are allowed to grow together, but the pruning of the old trees is done regularly to discourage growth and spread of black pod disease and allow sunlight to reach the young cocoa trees. The old trees are carefully cut down using a chainsaw or sharp cutlass immediately before the newly planted trees start fruiting.
- Improved chupon regeneration is the most complex of all the rehabilitation techniques. It requires expert consultation before its operation on any farm. The technique is recommended where trees on farms are of a low yielding variety and have become moribund. Following the procedure described for coppicing, above, the cocoa tree is coppiced at a height of 30 cm. The most vigorous chupon that develops at the base of the cocoa tree is then cut towards the tip, and the scion of an improved variety is budded onto the chupon. The chupon and scion are bound together with tape and the join allowed to heal ('take') before the tape is removed. This approach has an advantage over coppicing and chupon regeneration in that it provides an avenue for introducing new cultivars with better performance. For this method, the coppicing should be carried out around November and the new chupon budded with improved cultivars in March.

Institutions Contributing to Cocoa Rehabilitation

Assisting farmers in cocoa rehabilitation in the country has been a combined effort of several private and public organisations, who have encouraged and assisted farmers to rehabilitate their aged cocoa trees. These include CRIN, Cocoa Development Units (CDUs) and Agricultural Development Programmes (ADPs) of the Ministries of Agriculture of cocoa producing states, the Federal Government through the National Cocoa Development Committee (NCDC), the Sustainable Tree Crops Program (STCP) of the International Institute of Tropical Agriculture (IITA), and NGOs such as the Justice Development and Peace Commission (JDPC), and the Farmer Development Union (FADU). These organisations are involved in provision of extension and supportive services to farmers, while CRIN provides extension and research innovations. With so many players, it is important that contributions are defined and coordinated.

CRIN has worked in all cocoa producing states on the following specific activities:

- Provision of technical knowledge where necessary.
- Establishing seed gardens to ensure farmers have easy access to seedlings; this was funded by the Federal Government of Nigeria under the auspices of NCDC.
- Provision of improved materials for the seed gardens established by CDUs (see below).
- Provision of improved seedling materials to interested cocoa farmers.
- Training cocoa farmers on various techniques of cocoa rehabilitation with financial support from NCDC, and also in collaboration with mission organisations such as JDPC.
- Making farm visits to individual farmers to explain about appropriate methods for rehabilitating cocoa farms.

The CDU or Tree Crop Unit (TCU) of each cocoa producing state's Ministry of Agriculture has the following roles:

- Establishment of state seed gardens to make cocoa seedlings easily accessible and available to cocoa farmers at a subsidised rate.
- Linking up with CRIN in supplying pods from improved materials for the establishment of these seed gardens, hence ensuring that cocoa materials supplied to farmers are reliable.
- Providing extension agents to assist farmers with appropriate ways of rehabilitating their cocoa farms.
- Providing other inputs such as chemicals to cocoa farmers for the purpose of rehabilitating cocoa farms.
- Serving as the channel for distribution of inputs for cocoa rehabilitation provided by the Federal Government through NCDC.

Nursery site: community based nursery scheme of STCP-Nigeria at Ekperi Village, Edo State, Nigeria (Adeogun Stephen)

The Sustainable Tree Crops Program in Nigeria (STCP-Nigeria) efforts in cocoa started in 2003. They introduced the Farmer Field School (FFS) approach to solve the problem of low productivity among cocoa farmers in Nigeria (with yields around 475 kg/ha). This approach uses participatory methods to introduce farmers to the concepts of integrated crop and pest management (ICPM). The pilot stage of the project took place in Ondo State, which has the highest cocoa production in Nigeria. At present, STCP-Nigeria is contributing in the following ways:

- Training cocoa farmers and extension agents of the Ministry of Agriculture in cocoa producing states on ICPM through the FFS approach.
- Empowering cocoa farmers through the establishment and management of a cocoa nursery scheme, which was successfully trialled in four cocoa producing states. It was found to encourage the participation of cocoa farmers at the community level and has potential to ensure accessibility and availability of cocoa seedlings to farmers at the grass root level. It also encourages group formation among cocoa farmers; farmers who participated in the scheme are enthusiastic and willing to take it to the next level.

Farmers' Perspectives on Constraints to Cocoa Rehabilitation

Focus Group Discussion (FGD) was organised in Ondo State to determine farmers' perspectives on constraints militating against cocoa rehabilitation in Nigeria. They identified nine constraints using the Metaplan participatory tool (Table 2, column 2).

They were then guided to use pairwise ranking (another participatory tool) to categorise the constraints. This resulted in the constraints they had identified being ranked in the order shown in Table 2, column 1.

The ranked list shows that centralisation of training and assistance not reaching farmers are the most serious constraints, followed by lack of awareness on CRTs and Government officials not being committed to input distribution to cocoa farmers. The least important constraint according to the farmers is inadequate funding for rehabilitation.

Rank	Constraint
1st equal	Centralisation of training: the training organised by NCDC for farmers on rehabilitation in collaboration with CRIN is usually centralised in the cocoa producing state capitals, hence farmers complained of the distance and their inability to attend such training
	Government assistance/inputs not reaching the farmers
3rd equal	Lack of government official commitment to input distribution to cocoa farmers
	Lack of awareness of some cocoa rehabilitation techniques (CRTs)
5th	Sales of adulterated chemicals to cocoa farmers
6th equal	Poor pricing of cocoa
	Inadequate rehabilitation materials
8th equal	Farmers' reluctance to cut down cocoa trees even when no longer productive
	Inadequate funds for CRTs

Table 2. Constraints to cocoa rehabilitation identified and then ranked by farmers in Ondo State, Nigeria

Cocoa farmers during Focus Group Discussion (FGD) identifying constraints militating against cocoa rehabilitation in Nigeria (Adeogun Stephen)

Techniques	Highest possible adoption score	Respondents' mean adoption score	Adoption score (%)
Coppicing	8	2.5	31
Phased replanting	6	2.7	45
Young cocoa under old	9	7.7	85
Complete replanting	6	2.0	32
Gapping up	5	4.0	79
All techniques	34	18.9	55.6

Table 3. Cocoa farmers' adoption percentage score for CRTs in Nigeria

Adoption Level of Rehabilitation Techniques in Selected States

A further study (Table 3) revealed that Nigerian cocoa farmers' overall adoption level for CRTs is moderately high (55.6%). However, a very high adoption level is recorded for two CRTs: growing young cocoa under old trees (85%) and gapping up (79%); the lowest level of adoption is recorded for coppicing (31%).

These results indicate that, except for planting cocoa under old trees and gapping up, the adoption level of CRTs is still very low. This is an indication of the need to intensify efforts to strengthen the weak extension delivery system in the cocoa industry with respect to cocoa rehabilitation.

References

[1]ICCO (1999) Project on improvement of cocoa marketing and trade in liberalising cocoa producing countries. International Cocoa Organization, London, UK.

[2]Vos, J. & Krauss, U. (2004) Working with farmers. Ch. 12 in: Flood, J. & Murphy, R. (eds) *Cocoa futures. A source book of some important issues confronting the cocoa industry*. USDA/CABI Commodities, pp.141–149.

[3]RMR&DC (2004) Report on survey of agro-raw materials in Nigeria. Cocoa. Maiden edition. Raw Materials Research & Development Council, Federal Ministry of Science and Technology. Abuja, Nigeria.

[4]Agbelemoge, A.S. Adedoyin, F. & Oladoyinbo, S.D. (2001) Farmer's related factors and adoption of cocoa rehabilitation technology in Oluyole Local Government of Oyo State, Nigeria. *Moor Journal of Agricultural Research* 2.1, 83–85.

[5]Wood, G.A.R. & Lass, R.A. (eds) (1985) *Cocoa*. 4th ed. Longman, New York.

[6]CRIN (2001) Unpublished manual for training the trainers on cocoa rehabilitation techniques in Nigeria. Cocoa Research Institute of Nigeria, pp. 43–47.

By: Oluseun Adeogun, CRIN, P.M.B. 5244, Ibadan, Nigeria.
Email: adeogun_lizzyste@yahoo.com

Cocoa in Central America

Cocoa production in Central America (an estimated 5000 tonnes annually) is insignificant in the cocoa world market of over 3.5 million tonnes annually. However, at the local level, cocoa farming is of considerable importance to some extremely poor, indigenous (Ngabe, Bribri, Cabecar, Mayas, Mayangna, Miskito), afro-caribbean and mestizo small farmers, living in remote zones around protected areas of national and international importance. Cocoa production areas neatly coincide with the Mesoamerican biological corridor (Figure 1, p. 6).

Because of its non-perishable nature and high price per unit weight, dried cocoa can be efficiently stored on the farm and later transported economically to remote market places. Cocoa is produced in close association with a wide array of tree species (i.e. in agroforestry systems) and is credited with being an environmentally friendly land use. For interested readers, more about the value of cocoa agroforestry systems for biodiversity conservation and carbon storage (for the mitigation of climate change) can be found in recent reviews[1,2]. Poverty reduction, environmental conservation and cocoa farming are closely linked in Central America.

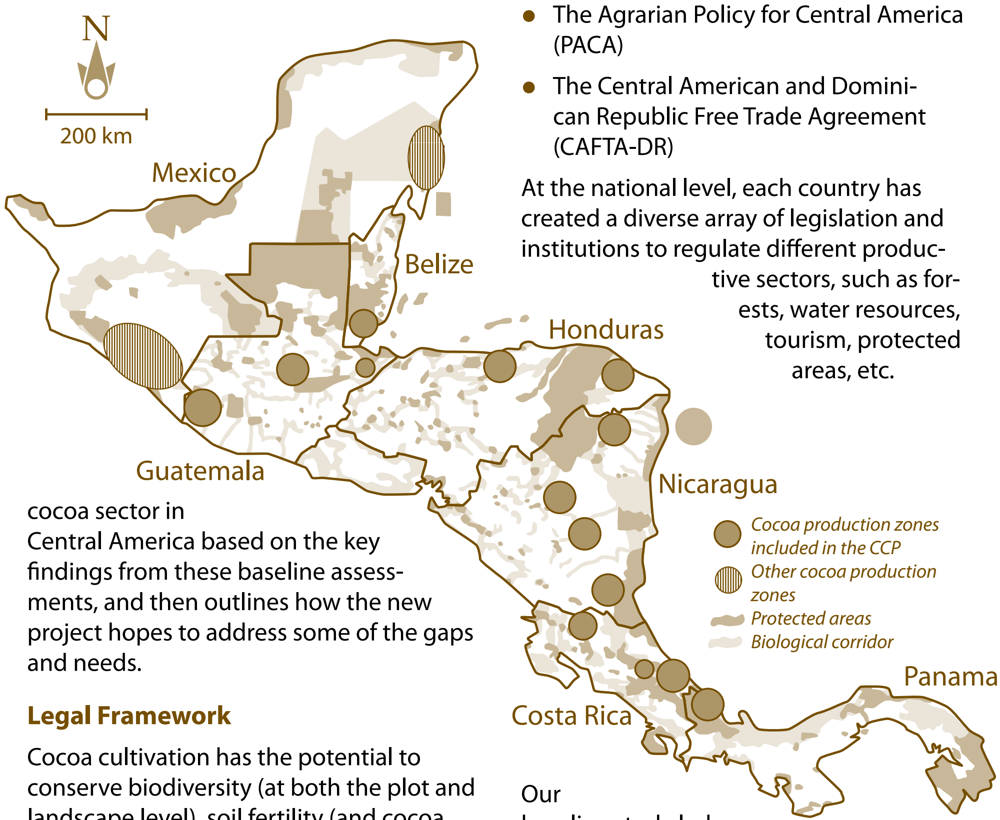
A new cocoa project has been recently launched by CATIE (Centro Agronómico Tropical de Investigación y Enseñanza) to increase both the competitivity of cocoa farming and the provision of environmental services to society[3]. The Central American Cocoa Project (CCP) is a US$5 million, five-year (2008–2012) project, which started in January 2008 with funding from Norway's environmental programme for Central America. The project is aimed towards both solving several key limiting factors (low yields, small production volumes, poor organisation and cooperation among farmers) and taking advantage of some opportunities in the Central American cocoa sector (political and financial support, keen interest of farmers and other actors in the cocoa value chains to rehabilitate the industry, the good quality of Central American cocoa offering secure markets and good prices to farmers, environmental services rendered by cocoa farming helping to secure markets and premium prices, etc.).

Baseline studies were conducted in 2007 in six countries (Panama, Costa Rica, Nicaragua, Honduras, Guatemala and Belize) in cooperation with eight cocoa farmers' organisations (CFOs) representing about 6000 families that cultivate some 8000 ha, produce approximately 1242 tonnes of dried cocoa annually, and purchase and trade a similar amount of dry cocoa from non-member cocoa families (see Table 1). The eight CFOs participating in this project are the main producers and exporters of certified (Fair Trade and organic) cocoa from Central America.

In 2007, the project began by assessing the legal framework that limits or favours the provision of environmental services in cocoa farms, together with the cocoa supply chain in each country and the role of governments and national educational systems in the cocoa sector. It also assessed the social cohesion and business performance of the eight CFOs participating in the project. It interviewed and inventoried 1500 cocoa families and farms and cocoa in communities where cocoa farming takes place.

This article provides an overview of the

Figure 1. Cocoa producing regions and protected areas in the Mesoamerican Biological Corridor. Adapted from: www.ecoworld.com/home/articles2.cfm?tid=377



cocoa sector in Central America based on the key findings from these baseline assessments, and then outlines how the new project hopes to address some of the gaps and needs.

Legal Framework

Cocoa cultivation has the potential to conserve biodiversity (at both the plot and landscape level), soil fertility (and cocoa productivity) and water, prevent soil erosion, and store atmospheric carbon in the wood of both cocoa and shade trees.

The following international, regional (Central American) and national legal, institutional and policy frameworks may favour or limit the provision of these environmental services in cocoa farms and landscapes.

At the international level, the relevant conventions and agreements include:

- The United Nations conventions on climate change, biodiversity conservation and protected areas, and desertification and drought
- CITES (Convention on the International Trade in Endangered Species of Wild Fauna and Flora)
- The International Convention on the Trade of Timber Species
- ILO (International Labor Organization) convention No. 169 on indigenous peoples

At the regional level, several policy instruments are in place and have the potential to influence the cocoa sector in its capacity to deliver environmental services:

- The Central American Forestry Action Plan (Spanish acronym: PAFT-CA)
- The Central American Alliance for Sustainable Development (ALIDES)
- The Central American Regional Environmental Plan (PARCA)
- The Agrarian Policy for Central America (PACA)
- The Central American and Dominican Republic Free Trade Agreement (CAFTA-DR)

At the national level, each country has created a diverse array of legislation and institutions to regulate different productive sectors, such as forests, water resources, tourism, protected areas, etc.

Our baseline study led us to conclude that current legal and institutional frameworks on water resources and soil conservation are very sketchy, to say the least. Most national legislation on environmental issues in Central America was created more than ten years ago and has a strong sectoral approach (soils, water, fauna, forests, etc.) instead of the integrated approach that is required for dealing with the provision and marketing of environmental services. However, Costa Rica is a notable exception, having created the legal and institutional frameworks for the promotion and administration of the environmental services provided by both natural forests and agricultural lands.

Governments, Communities and Education

The cocoa sector has little relevance and political weight in most Central American countries. However, current high prices for cocoa have motivated governments, donors and NGOs to promote the cultivation of cocoa as a means to reduce poverty in remote, economically depressed regions. All Central American countries now include cocoa in their agendas and both financial and political support are given to the rehabilitation of the national cocoa sectors. Universities (agronomy departments) and technical high schools have not included cocoa in their curricula in the last 15 years; the only two notable exceptions are the Faculties of Agronomy of the Central University of Belize and the Universidad de San Carlos in Guatemala. Sustainable cocoa production could easily be included in the curricula of the 393 primary schools (an estimated 8000 sixth graders), 56 high schools (1800 senior students) and more than 30 agronomy departments (900 senior students) of the Central American universities.

Farmers' Organisations and Cocoa Farms

Cocoa farmer organisations (CFOs) differ widely in their social cohesion and business skills. All CFOs need better strategic plans (to focus on the clients and not the product), to improve the quality of the services they provide to their associated families, and to improve their physical infrastructure and administration (especially accounting and finances).

Cocoa is the primary crop for 50% of the farms; for the rest, cocoa production is the second or third most important crop in terms of farm income. In Panama and Costa Rica, the livelihood of farmers is based on the cultivation of bananas (and/or plantain), cocoa and slash-and-burn rice. In Nicaragua and Honduras, farmers are subsistence livestock (cattle) producers who also cultivate cocoa and oranges as cash crops, and slash-and-burn beans, maize and rice for self-consumption. In Guatemala and Belize, farmers cultivate cocoa, oranges and annato (*Bixa orellana*) as cash crops, and slash-and-burn maize and rice for self consumption. The average annual gross income from cocoa production is US$315 per household. Cocoa families in all Central American countries are below the US$2.18/day poverty line. Mean monthly income per family is US$107, covering only 52% of monthly family basic needs.

Cocoa Cultivation

Cocoa is cultivated at 100–800 m altitude in small plots (1.2 ha/farm) with low yields: 75–150 kg/ha/year in zones with frosty pod rot (*Moniliophthora roreri*) and with poor management; and 200–350 kg/ha/year where there is frosty pod rot and minimal management (Table 1). Cocoa trees are typically spaced at 4 × 4 m (625 plants/ha) in most countries. Hybrid seed (from either controlled pollination or pods selected on local farms) was used to establish most cocoa; grafted cocoa is scarce and has been established only during the last decade. Most farmers have two or more cocoa plots per farm.

Cocoa is poorly pruned, cocoa trees are 4–6 m tall and shade canopies are poorly designed and managed. Shade tree density is in the range 85–166 trees/ha (Table 1). Most trees are planted and some spe-

Organisation	Total area (ha)	Altitude (m)	No. of families	Total cocoa production[a] (t/year)	Cocoa yield (kg/ha/year)	Area of cocoa/family (ha)	Cocoa trees/ha	Shade trees	
								No./ha	No. species/1000 m²
Belize: TCGA	827	112 ± 79	1034	62	75	0.80±0.25	750 ± 13	92 ± 40	6±3
Guatemala: ADIPKAKAW	1350	385 ± 142	1800	344	255[b]	0.75±0.25	700 ± 25	198 ± 75	6±2
Guatemala: APROCA	66	350 ± 171	66	14	210	1.0±0.50	650 ± 25	194 ± 50	9±4
Honduras: APROCACAHO	450	171 ± 150	300	55	122	1.50±0.75	750 ± 25	108 ± 55	7±2
Nicaragua: CACAONICA	932	373 ± 171	548	305	328	1.70±0.70	800 ± 12	118 ± 35	8±3
Costa Rica: APPTA	1612	160 ± 177	1180	400	247	1.40±0.80	700 ± 38	137 ± 470	8±2
Costa Rica: ACOMUITA	105	120 ± 177	70	7.5	71	1.50±0.50	650 ± 25	124 ± 30	8±2
Panama: COCABO	2614	106 ± 97	868	55	61	3.0±1.50	750 ± 25	85 ± 30	6±2
Total	7956		5866	1242.5	-	-			

[a]Dried cocoa beans.
[b]Frosty pod rot (*Moniliophthora roreri*) not present.

Table 1. Cocoa farmer organisations and cocoa agroforestry systems in Central America

cies are selected from the natural regeneration. Shade trees are used for timber (*Cordia alliodora*, *Cedrela odorata*), fruit (*Musa* spp., *Citrus* spp., avocado, coconut, peach palm [*Bactris gasipaes*], mango) and shade (*Inga* spp., *Gliricidia sepium*). Tree canopies have three vertical strata (low <10 m, medium 10–20 m and high >20 m tall), containing 50%, 30% and 20% of total tree density, respectively.

The Way Forward under the CCP

The main goal of the CCP is "to improve the capacities and cooperation among at least 6000 cocoa families, eight cocoa farmer organisations, governments, and educational centres (primary schools, technical high schools and universities) to increase the competitiveness and provision of environmental services of cocoa farming in Central America". The CCP is organised around five components:

1. Productivity and environment. Improving cocoa genetics at the farm level; developing agroforestry for shade regulation and product diversification; and enhancing provision of environmental services.
2. Cocoa farmers' organisations (CFOs) and business competitivity. Encouraging social cohesion and business performance.
3. Cooperation and impact. Attracting financial, technical and political support to the cocoa sector; improving cooperation between CFOs and other actors at both local and national level; and scaling out innovations of the CCP to other regions within each country.
4. Education and communication. Running farmer field schools (FFS) for at least 6000 cocoa producing families; encouraging modern cocoa cultivation in curricula of educational centres; and producing publications for FFS, radio, video, the web, etc.
5. Participatory project management. The CCP is being implemented in close cooperation with CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France), FHIA in Honduras (Fundación Hondureña de Investigación Agropecuaria), FAUSAC in Guatemala (Facultad de Agronomía de la Universidad de San Carlos), Fundación Natura in Panama, ACICAFOC (Asociación Coordinadora Indígena y Campesina de Agroforestería Comunitaria Centroamericana), Bioversity International, ProMundo Humano, Lutheran World Relief, IICA (Inter-American Institute for Cooperation on Agriculture) and other partners.

References

[1]Schroth, G. & Harvey, C. (2007) Biodiversity conservation in cocoa production landscapes: an overview. *Biodiversity and Conservation* **16**(8), 2237–2244.

[2]Somarriba, E., Andrade, H.J., Segura, M. & Villalobos, M. (2008) ¿Cómo fijar carbono atmosférico en fincas Bribri y Cabécar (Talamanca, Costa Rica), certificarlo y venderlo para obtener ingresos complementarios a los productores? *Agroforestería en las Américas* **46**, 81–88.

[3]CATIE (2007) Competitividad y ambiente en los paisajes cacaoteros de Centroamérica. Documento de Proyecto. CATIE, Turrialba, Costa Rica, 155 pp.

By: Eduardo Somarriba, Marilyn Villalobos and Luis Orozco, CATIE, Turrialba, Costa Rica.
Email: esomarri@catie.ac.cr; marilynv@catie.ac.cr; luisoroz@catie.ac.cr

What's New for Witches' Broom?

The change of name, from *Crinipellis* to *Moniliophthora perniciosa*, signalled just one advance in understanding the causal agent of witches' broom disease. A recent publication[1] summarises developments in systematics, fungal physiology, biochemistry and genomics and gene expression, and highlights what more needs to be known to improve management of the disease.

Improvements in culturing techniques together with substantial progress with genome and gene expression studies have shown that the two distinct growth phases that characterise the fungus have important metabolic differences, and have provided insights into the biochemical and physiological nature of the disease process. This has improved understanding of the fungus–host interaction, and may eventually help explain how such pathogens cause diseases in many crops.

The fungus has a number of biotypes of which only one (biotype C) infects *Theobroma cacao*. The use of molecular markers to measure both host-specificity and genetic variability in this biotype in different geographic regions has given credibility to the story of two separate introductions to Bahia, Brazil, and confirmed that these were probably from Amazonian populations. Current studies are investigating the molecular basis of why resistance to *M. perniciosa* breaks down in SCA (Scavina) clones that have formerly shown resistance.

Marker-assisted selection and QTL (quantitative trait loci) mapping are being used to accelerate development of disease-resistant clones through improving the understanding of the host–pathogen interaction. Important facets include studying the genetic basis of the varying pathogenicity in different *M. perniciosa* populations, and of host resistance in SCA clones – and exploration of this in germplasm groups other than SCA needs to be pursued.

Trichoderma spp. have been touted as biological control agents for witches' broom disease. Commercial formulations of *T. stromaticum*, which parasitizes the external basidiocarp and saprotrophic mycelium, have been most successful, but results are variable possibly because of climatic factors. Activity of a promising endophytic species, *T. ovalisporum*, may also be compromised by these factors, indicating the need to know more about the relationship between the cocoa forest environment and establishment and survival of biocontrol agents.

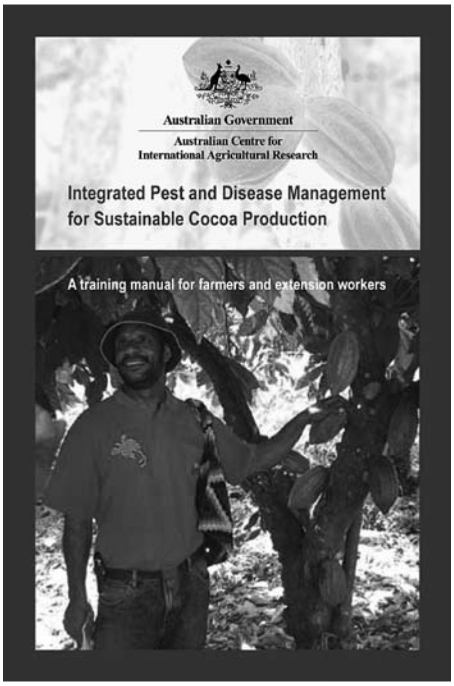
Although brooms are the fungus' trademark, we need to learn more about both the infection process of *M. perniciosa* and the progression of the pod rot disease which actually causes most production loss. In addition, basic existing knowledge about pathogen diversity needs to be related to disease interaction on the resistant tree lines developed so far, and populations of the fungus need to be mapped across the cocoa producing regions they occur in. Combined, these would allow a strategy to be developed whereby only trees resistant to the prevailing fungal population were planted, to help prevent resistance breaking down.

On a broader scale, the authors call for proactive programmes, involving farmer education and regional action plans, in cocoa growing regions of the world currently free from witches' broom disease. Moreover, knowledge gaps need to be filled to allow risks of its trans-regional spread to be quantified and minimized; methods developed for this could then be applied to other severe but currently regionalized diseases such as frosty pod rot (*M. roreri*) and *Phytophthora megakarya* black pod disease.

[1] Meinhhardt, L.W, Rincones, J., Bailey, B.A., *et al*. (2008) *Moniliophthora perniciosa*, the causal agent of witches' broom disease of cacao: what's new from this old foe? *Molecular Plant Pathology* **9**(5), 577–588.

Contact: Lyndel Meinhardt, USDA-ARS Sustainable Perennial Crops Laboratory, Beltsville, MD, USA.
Email: lyndel.meinhardt@ars.usda.gov

ACIAR Manual



Developed to assist farmers to optimise their cocoa production in Papua New Guinea (PNG), a sturdy, ring-bound, hand-sized manual from ACIAR (Australian Centre for International Agricultural Research) provides essential information on integrated management of cocoa pests and diseases found in the region[1].

The manual is intended to be used alongside training, and its colour figures and informative methodologies mean it can be used as a ready reckoner in the field. It addresses knowledge gaps in cocoa production and explains new management approaches, based on sound agronomic practices and integrated pest and disease management strategies. It has been written to accompany 'Classroom in the cocoa block' training, part of a suite of projects funded by ACIAR in PNG that addresses gaps in cocoa production.

It contains useful and practical advice on topics such as pruning of cocoa and shade trees, weed control, fertiliser and manure use, sanitation, and insect pest control, covering disease vectors and cocoa pod borer. The underlying principles of improved cocoa management apply not only to PNG but to other cocoa-growing regions.

To quote Peter Core, Chief Executive Officer, ACIAR. "Farmers can expect significantly higher yields if these approaches are implemented completely and correctly."

[1] Konam, J., Namaliu, Y., Daniel, R. & Guest, D.I. (2008) *Integrated pest and disease management for sustainable cocoa production: a training manual for farmers and extension workers*. ACIAR Monograph No. 131. Australian Centre for International Agricultural Research, Canberra, 36 pp.

The manual can also be downloaded free of charge from:
http://www.aciar.gov.au/publication/MN131

16th ICRC: Key Information

Organised by the Cocoa Producers' Alliance (COPAL) and in conjunction with the Government of Indonesia, the 16th International Cocoa Research Conference will be held on 16–21 November 2009 at the Hyatt Hotel, Nusa Dua, Denpasar, Bali, Indonesia.

The theme of the conference is: 'Towards Rational Cocoa Production and Efficient Use for a Sustainable World Cocoa Economy' and will include sessions on the following subject areas:

- Genetics and breeding
- Agronomy, agroforestry, physiology, soils and nutrition
- Pests and diseases
- Chemistry, technology and quality
- Efficient utilisation of cocoa and cocoa by-products
- Improvement of cocoa consumption through generic promotion
- New and non-traditional uses of cocoa
- Transfer of technologies and efficient utilisation of the results from cocoa research
- Marketing and socio-economics
- Other aspects of research including environment

Deadlines for submission of summaries and full papers are 31January 2009 and 30 June 2009 respectively. Intending participants should register by 1 September 2009.

The Conference will be followed by the INGENIC, INCOPED and INAFORESTA meetings on 23–25 November 2009.

Further information: www.copal-cpa.org

Global Research On Cocoa (GRO-Cocoa) is produced biannually (June and December) with financial assistance from the US Department of Agriculture (USDA) by:

CABI Europe – UK, Bakeham Lane, Egham, Surrey TW20 9TY, UK

Email: CABIeurope-uk@cabi.org
Fax: +44 1491 829100
Website:
www.cabi.org/datapage.asp?iDocID=475

Editors: Mrs Rebecca Murphy
Dr Keith Holmes
Miss Sarah Thomas

Send correspondence, contributions and enquiries to the Editors, postal address/fax as above, or email:

GRO-Cocoa@cabi.org

The views expressed in this newsletter do not necessarily reflect those of USDA, CABI or the Editors. You are welcome to use the text of the newsletter (unless copyright is assigned otherwise), but please contact the contributor or the Editors first, and acknowledge *GRO Cocoa* as the source. Where image ownership is acknowledged, contact the owner (via the Editors if necessary) for permission to use.

www.cabi.org USDA