1998-2002 Programming

CIRAD Tree Crops Department (CIRAD-CP)

Centre de coopération internationale
en recherche agronomique
pour le développement

CIRAD Tree Crops Department
(CIRAD-CP)

1998-2002 Programming

Centre de coopération internationale
en recherche agronomique
pour le développement

CONTENTS

02/06/98

INTRODUCTION

The CIRAD Tree Crops Department, CIRAD-CP, was created in November 1992 by merging the Research Institute for Coffee, Cocoa and other Stimulant Crops (IRCA), the Rubber Research Institute (IRCC) and the Oils and Oil Crops Research Institute (IRHO). The merger was part of a departmental reform requested by the Ministry of Cooperation and the Ministry of Research; the project was submitted to the CIRAD Board and approved on 11th December 1991.

At the end of the first five-year programming plan (1993-1997), which organized operations around five programmes (cocoa, coffee, coconut, rubber and oil palm), and seven discipline-oriented research units, CIRAD general management commissioned an external review. The external review committee submitted its report at the end of September 1997. The report was used by the CIRAD scientific programming and coordination committee, general management and scientific committee as a reference when drafting the guidelines of a new five-year plan.

The external review and drafting of the new five-year programming plan for 1998-2002 coincided with a fundamental reform of CIRAD, which has now been split into seven departments grouping three major types of programmes: commodity channel programmes, ecoregional programmes, and scientific support programmes.

The five-year plan describes the strategy that the department intends to apply in the coming five years. Its purpose is to enable the department to identify the stakes involved in its operations, along with its partners and their requirements, in order to galvanize its forces to meet the challenge. Such programming is also essential for the department in establishing its relations with the research teams working in other CIRAD structures, in a context of clear objectives and pre-defined resources.

The department also has to cope with limited human and financial resources. The projects in which its expertise is to be invested have to undergo careful selection, and at least address the priority challenges facing development-oriented research, taking an acknowledged scientific approach.

Lastly, this document is a reference for assessing the department's results. It will be revised annually and adapted to environmental conditions.

OVERALL CONTEXT

Changes in the economic and institutional context

The world has changed more in the last five years than in the previous four or five decades. A global economy is emerging with the end to agreements on commodities, market segmentation and the appearance of new stakeholders, along with the greater role played by private enterprise. This new situation is contributing to worsening South/South competition and is fuelling the demand for competitiveness in the agricultural sectors. Environmental conservation is also imposing new constraints, with particular emphasis on sustainable development.

This change also goes hand in hand with a profound modification in development aid and the corresponding flow of financial resources: reduction in state aid, which is channelled less and less to the production sectors, the gradual primacy of private investment in line with State withdrawal, an ongoing search for greater profitability, etc.

The impacts of such a policy can be seen everywhere, but the tropical zone of Africa is particularly sensitive. Development of neo-liberal policies, and especially the structural adjustment reforms that began in the late 80s and extended into the 90s, led to a cut-off in aid to the agricultural sector from 92 to 97, particularly for inputs, then to withdrawal of the parastatal companies responsible for input supplies, and lastly to the disappearance of seasonal credit systems. As private enterprise had yet to take over from the public institutions, and the smallholder associations were not sufficiently well organized, the resulting institutional vacuum led, in practice, to minimum risk taking by producers, primarily with a disinvestment in inputs and the abandonment of certain innovations.

However, current trends also provide hope of an end to the commodities crisis that has been particularly acute since the beginning of the 80s. Renewed competitiveness should enable poor and marginalized countries to get back into the world economy, provided the current crisis in certain Asian countries is controlled.

National agricultural research systems, which are used to proposing technical innovations for improvement of production factors to State organizations responsible for their dissemination, have rarely been able to adapt to the new situation and have become marginalized. Some are on the way to semi-privatization. Lastly, development in the sciences and communication techniques has also had an impact on agricultural research over the same period. The research community (ARI, NARS, IARCs) has thus agreed on the institutional procedures that need to be established to accompany a process of internationalization of agricultural research within a global system.

Changes in research-development concepts

During the colonial period and the ensuing years there was great faith in agricultural development, especially for export crops, which were to guarantee the earnings of States that were mostly devoid of any other raw materials. That period also corresponded to an opening up of the countryside and a decisive move towards the monetarization of agriculture. Thus, within one generation, a major rural population moved from subsistence farming and exchanges in kind to production for a market.

Like the former colonial powers or dominant nations of the North, the economy of those countries was then governed by principles of State planning, for production with the organization of integrated commodity channels or the creation of estate plantations, for harvest collection (sometimes with a purchasing monopoly), for processing, and for marketing and export with the creation of stabilization funds in tropical Africa.

Agricultural research contributed to such developments, primarily by working on production factors: improved varieties for productivity, crop protection, fertilization, etc., along with crop management sequences that combined these factors and were likely to maximize production in a given physical environment. There can be no doubt as to the value of the agricultural results and it is now known that it is perfectly possible to obtain high yields in sub-Saharan Africa with more or less all the plants corresponding to the different ecologies of that zone, which was still a controversial issue in the 1960s.

However, forty years after independence, the ultimate impact of research is highly contrasted and can be summed up in two statements:

- agricultural development owes more to political and socio-economic policies than to innovations resulting from research,

- research results were only applied once socio-economic conditions had been mastered, at least partially. That was the case on estate plantations (oil palm, rubber, sugar cane) and for smallholdings in a context of integrated commodity channels (cotton). On the other hand, crops such as coffee, cocoa, rice or maize developed primarily through an increase in the areas planted and more rarely through increased yields and productivity.

Furthermore, this assessment is made in an economic context that is completely different from the one that prevailed when the major development plans were launched. Neo-liberalism has replaced State planning, with less and less State intervention in the direct organization of production and marketing; the estate plantations have been privatized or are about to be so, and most of the integrated production channels are undergoing profound changes. This situation is not without consequences for national research operations; for instance, there has been a loss of traditional relays with production, a severe drop in public funding and, in some countries, a process of semi-privatization is under way.

Under such conditions, it is easy to see why research sometimes has a few problems finding its feet and why researchers have difficulty in pinpointing a demand, which still exists, but which has become diversified and often changed in nature. Demand for the improvement of production factors is still around, but is limited to estate plantations, for which the environment is relatively well-known and controlled. Outside the estates, needs are not formulated in technical terms, and in order for them to be understood, a producer socio-economics approach needs to be taken. Indeed, few people still believe in an agricultural revolution in developing countries through the introduction of "miracle solutions" in terms of planting material, agricultural techniques or inputs.

Research is therefore concerned by the recent history of development and it needs to give thought to the highly unequal successes met by innovation transfer. In fact, the linear approach needs to be questioned, whether it be of the "creation-propagation" type or the "T and V" type, to achieve a more global approach, for which technical themes are perceived in a previously defined environment, whether the environment be a farm, a rural area or a small region. The same global approach is required for primary processing.

Initially, this *system* approach was broadly centred on farms. However, the intervention zones virtually always have a dominant crop, which serves as the linchpin for the farmer's organization of his agrosystem, and also induces the connection with a commodity channel bringing together the different stakeholders involved in the various stages of production and marketing. It is that commodity channel that ensures the major share of relations between farms and the outside world and therefore serves as a guide for insertion of stakeholders from production right up to the international markets. The key to success for development-oriented agricultural research no doubt lies in the combination of "farming system" approaches and "commodity channel" approaches. In brief, the issue needs to be that of agricultural income in a "region" in which an export crop dominates, and no longer just the effectiveness of production factors on the dominant crop.

Furthermore, whilst the constraints associated with productivity and quality are clearly identified by a commodity channel approach, the same cannot be said of an analysis of comparative advantages between the different commodity channels; it is by taking a global look at the strategies of the development operators in a given region that such an analysis, and consequently, the possibilities of diversification need to be approached.

Thus, research programming is no longer designed without an analysis of the objectives and strategies of the individual or collective stakeholders, hence of decision-making methods in relation to the constraints and opportunities of their environment. Lastly, agricultural research must incorporate skills on three levels: regional diagnosis and farm typology, development of transferrable technical innovations and mobilization of the scientific skills required.

Internal changes at CIRAD

In 1992, given the agro-industrial sectors covered by the merger of three institutes, the CIRAD-CP programmes received a mandate to work on the production of smallholdings and estate plantations, and on processing and commercialization of the marketable products. The programmes therefore had to ensure a socio-economic component geared towards a clearer understanding of conditions on smallholdings and, at the same time, develop their relations with private companies. Thus, in 1992, the department received a double mandate covering tree crop commodity channels and the farming systems into which those tree crops were integrated.

The mandate was implicitly confirmed in July 1996 by the signing of a contract of objectives between CIRAD and the State which promoted research in three fields: improvement of production sectors and processing techniques, consideration of stakeholder behaviour within the economic and institutional environment, and economic and sustainable management of land and natural resources.

The mandate was also confirmed by the recommendations of the Scientific Committee on 14th October 1997, which nevertheless requested that the commodity channel approach be justified with respect to other approaches, such as analysis of family-run farms or farms on newly cleared forest land.

Up to the end of 1997, CIRAD-CP was divided into two entities for implementation of its activities: programmes and research units. Since 1st January 1998, in accordance with the general principle of CIRAD organization, the CP department has been run on the lines of the set of commodity channel programmes that already existed in the previous organization. These programmes are the operational side of the department's mandate and the targeted activity of part of the centre's scientific operations.

The commodity channel programmes are backed up by thematic scientific support programmes and completed by ecoregional programmes involving the whole of CIRAD. The scientific support programmes are required to provide answers to questions raised by the other, commodity channel or ecoregional programmes.

Relations between the commodity channel programmes and the scientific support programmes are established on a contractual basis.

Recommendations of the external review and of the scientific committee

"After an analysis of the commodity channels involved, the scientific disciplines and the operation of the department, the commission put forward strategic and operational proposals.

In the scientific fields, for varietal improvement the report recommends renewing conventional breeding programme approaches and ensuring effective coordination between "molecular" research and conventional breeding. It is also necessary to more effectively ensure relations with agronomy and crop protection work, and the latter discipline must also make more rational use of molecular biology tools. The utility of modelling in the agronomy field is acknowledged, provided dispersion of the research issues is avoided and provided the crop management sequences of producers are taken into account, in order to achieve operational models rapidly. Chemistry and technology have thematic specificities (e.g. in the field of oils) on a national scale that need to be asserted through more effective positioning with respect to the other French laboratories, and by seeking closer collaboration than that which currently exists; moreover, it is essential to give careful thought to the concept of quality before embarking upon extensive research in this field. Lastly, in terms of economics, work on commodity channel economics needs to be completed urgently, with a study of the socio-economic conditions for the functioning of smallholdings, on which the future of tree cop development depends. Relations with the "Humid Tropics" ecoregional programme and with the "Smallholder Farming" programme will therefore be decisive in that respect and they should be formalized with care.

According to the commission, the base centre concept for implementation of research in the field is an outmoded concept and should be abandoned. On the other hand, the department could concentrate its resources in a "target country" per continent, in order to have sufficient "critical mass" to operate effectively in the country and in the subregion.

Regarding the organization of the department, the commission does not have any clear-cut opinion on the number of programmes to be implemented, but acknowledges the merits of the commodity channel approach, provided the corresponding programmes are not weakened by the departure of too many researchers to ecoregional and scientific support programmes. Furthermore, maintaining the commodity channel programmes will require serious rebalancing of staff numbers between Montpellier and overseas, and a strategy of installation in proximity to the major producers of the products involved will have to be defined and implemented.

According to the commission, the operation of the department is seriously affected by a loss of substance and potential, directly linked to the departure of a large number of senior researchers who have not been replaced through recruitment. Most of the global indicators of dynamism and outside recognition of the activity are deteriorating (publications, contractual resources, theses, scientific support missions, age pyramid, Montpellier:overseas ratio, etc.) and some of them are likely to continue declining if the research potential is not rebuilt.

Faced with this disturbing situation, the commission makes a few recommendations to the department and to CIRAD General Management.

It is necessary first of all to assess the importance of tree crops research activities at CIRAD and draw the necessary conclusions as regards the recruitment of young researchers in strategic sectors that the new five-year plan is intended to bring out. It is then indispensable to establish budgetary programming per objective that is coherent with the scientific programming, and to organize a veritable "personnel" function. Such a service can only be conceived close to the researchers, hence with an Administrative and Financial Management based in Montpellier.

As regards contractual resources, the commission draws attention to the risks of strong demands for a significant increase in such resources, without prior analysis of their content. If it means more effective application of research results, hence increasing the stock of results available beforehand, then such demands are legitimate; if, on the other hand, it means multiplying expertise missions, it is clear that such an option would affect the department's ability to innovate and produce scientific results likely to be of interest to its potential partners. It is important to keep these stakes in mind for the coming five-year programming exercise.

Recommendations of the external review and of the scientific committee (end)

After presentation of the external review conclusions, the scientific committee recommended that the department:

- express its scientific project in terms of questioning, issues and methods and not to refer solely to products or plants at which the research is directed. The reasons for dealing with problems by a commodity channel approach need to be justified with respect to other approaches, such as family farms or farms on newly cleared land;

- galvanize all its necessary skills or skills from outside the department and complete them, for instance by establishing close ties with the Humid Tropics and Smallholder Farming programmes and, of course, with the scientific support programmes.

TREE CROP STAKES IN THE HUMID TROPICS

Global development challenges in the humid Tropics

Over and above major disparities linked to their history, demography and access to major lines of communication, the humid Tropics incorporate a combination of factors that form the basis of their originality: the existence of forests, and of perennial tree crops, the decisive clout of markets and urban growth, specific problems for sustainability management. According to a recent overview[1], the major challenges facing farmers in the humid Tropics are threefold:

Satisfy the demand for food

Population growth is considerable in the humid Tropics, the process of urban concentration is not slowing down and the population increase in those zones is set to remain high in the next decade.

Consequently, although exports of tropical produce used to be the driving force in the economy of most countries in the humid Tropics, it is no longer the case today for everybody and many South American and Asian countries have the potential for reviving their agricultural growth based on domestic demand, especially urban demand, which has become solvent and regular overall. However, such solvent demand has remained weak and fragile in Africa, where the transition will probably be more gradual.

Unlike in Asia, where smallholders have already developed highly labour- and input-intensive farming systems, taking up this food supply challenge will only be possible in the tropical zones of Africa by intensifying the use of land, to which access will also become increasingly problematical due to land saturation because of an end to the extension of forest clearance. Depending on the regional situation, tree crops will also have to undergo the same process of intensification if they are to remain competitive in relation to food crops.

Achieve integration in international exchanges

Even though the financial resources derived from tree crops have become secondary in South American countries, and are in relative decline in Southeast Asian countries, they remain important in Southeast Asia for the rural communities involved, and are essential for countries in the humid tropical zone of Africa, in which export-oriented agricultural sectors remain an unavoidable pillar of overall growth and rural development. For all those countries, they are often the best guarantee against poverty and the marginalization of rural societies.

For these agricultural-exporting sectors to remain a driving force, it is necessary for each of them to improve its international integration, whilst remaining competitive on the market.
Such integration can be achieved by increasing production, but in environments where prospects of increasing yields by extending the areas planted on newly cleared forest land are decreasing year by year, it means that the production systems have to evolve towards greater intensification. Greater crop security can also be achieved by producing better, whilst seeking to reduce production costs. Lastly, integration can be achieved by improving or regularizing the quality of the raw product, so

---

[1] 1996 : Les agricultures des zones tropicales humides, éléments de réflexion pour l'action, Ministry of Cooperation, 317 pages.

that specific niches can be more effectively targeted, and the definition of quality will have to go beyond simple organoleptic properties and incorporate the possibility of attributing special labels (organic, ethical, etc.).

In the longer term, competitiveness will also involve the diversification of export products, through the installation of processing industries in producing countries.

Ensure the sustainability of agricultural performance

Maintaining the durability of an activity that contributes towards economic and social growth presupposes that the conditions that enable such production do no deteriorate. For agricultural production in the humid Tropics, that primarily means the fertility of the soils, which are usually more fragile and subject to greater aggression (heavy rainfall) than in other zones, and crop protection, which is often the main limiting factor.

Under the current conditions in most of the States involved, these requirements are often contradictory to immediate competitiveness objectives, and to population growth and the resulting land occupation pressure; all the more so since smallholdings often do not have access to inputs, or to techniques that would enable them to conserve their soils and protect their crops. Furthermore, traditional fertility restoration techniques involving long fallow periods are increasingly difficult to implement given the current land saturation process.

The sustainability challenge therefore means proposing technical innovations, but their introduction requires a political, legal and economic context that favours their adoption by producers. This challenge concerns both the States, the international community, and agribusinesses.

Specific challenges linked to tree crops

The commodity channels linked to tree crops are often very diverse, with specific stakeholders, especially as regards trading in the raw products, processing and industrial requirements. However, when the prospects for these commodity channels are examined from political and economic angles, the same dominant tendencies are found:

▸ tree crops remain a driving force in the economies of most countries in the zone and they help to integrate those countries in international exchanges. They are also a factor of social structuring and local development,

▸ world demand for the raw products is not declining and is even tending to increase for some of them (palm oil, rubber, cocoa),

▸ ongoing globalization entails a reduction in the control that States have over their own production, quota policies have been and gone, as have administered and guaranteed prices; recognition of quality is going to depend less on the origin of the exporting country than on the production zone (name of origin), combined with the reputation of the producers and traders. The situation is moving towards diversification of *terroirs* and of quality criteria,

▸ this free market situation is pushing stakeholders in the commodity channels to acquire an ability to think ahead, drawing up production, marketing and processing strategies according to the markets and the competitors. For marketing and processing, a very strong concentration of trading and processing companies can be seen, accompanied by relocation to the producing countries for primary processing. In fact, large firms are implementing different strategies to guarantee supplies, in terms of quantity and quality, and direct involvement of those firms in production, which had only been marginal till now, could be stepped up,

▸ market segmentation is also occurring, along with reorganization of the commodity channels as a whole. It is also a challenge for research to accompany the emergence of new types of coordination, taking into account the imbalance in the forces and the need for isolated producers to group together,

▸ the future no longer belongs to large State-run plantations, and only private capital will be able to fund new estate plantations. In the smallholder sector, there is strong demand in West Africa for palm oil and rubber, bringing those crops closer to the issues faced in cocoa and coffee cultivation.

On a farm level, tree crop production systems offer the advantage of guaranteed exploitation over a time span that can be very long - sometimes several generations - in a delimited area in which the farmer ensures his ownership. Moreover, they provide cash income that is often essential for his farm and the region involved. However, such permanent exploitation also has its constraints[2]:

▸ the benefits of the work involved are only obtained several years after the initial investment and they largely depend on the care given to the crops during their establishment phase. This time lag limits the flexibility of adaptation to circumstances and the adoption of certain innovations, especially in the field of replanting,

▸ income depends on a market, over which producers, and usually the country, have no control,

▸ the crops are usually grown on newly cleared forest land, where "mining extraction" is dominant and becomes the rule when prices are low. Degradation of the soil can then lead to situations that are hard to reverse.

Phytosanitary problems also increase with sedentarization.

Ensuring the sustainability of tree crops under greatly fluctuating market conditions requires that agricultural research propose a certain degree of variability in its recommendations, to enable rapid adaptation of crop management sequences that ensure they remain competitive. Producers need more resources at their disposal to manage the increased risks associated with market liberalization.

Such competitiveness involves an improvement of work output: producing more but especially producing better, by concentrating on quality/security, but also through more effective organization of domestic markets.

Lastly, CIRAD needs to seek new forms of intervention and partnerships, which can be defined along three lines:

▸ international integration of producers (through volume, prices and (or) quality),
▸ new ways of coordinating stakeholders in the commodity channels,

---

2 Oliver, R. and B. Tailliez, 1995 - Systèmes de cultures pérennes, *in* Fertilité du milieu et stratégies paysannes, Actes du séminaire, *Colloques Cirad*, page 383.

▸ the flexibility of production and processing tools, in response to fluctuations in international market conditions.

CIRAD-CP STRATEGY

In order to meet the challenges involved in the development of tropical zones through tree crop commodity channels, CIRAD needs to develop a strategy for action that takes into account the opportunities and constraints of an environment that is in the midst of economic, political and scientific change. Its evolution needs to be monitored on a continuous basis, in order to seize opportunities linked to new situations, whilst leaving aside those that are linked to the past and in which it risks becoming marginalized.

CIRAD-CP also needs to revise its position within CIRAD, which has been reorganized on a new basis in which thematic activities have been grouped, mostly in specialized structures. The department will therefore have to renew its collaboration in the scientific field and establish new areas of collaboration. It will also be essential to develop research in terms of diagnosing requirements and transferring results to smallholdings, which are often the most important productive sector. There again, it is necessary to establish new relations with the ecoregional programmes, but also with the scientific support programmes, in which the sought-after skills are to be found.

In order to establish its strategy, the department will therefore have to define its main lines of research and the priorities that need to be fixed, the internal and external partnerships it intends to strengthen or establish, and lastly, the geographical zones on which it is to concentrate.

Lastly, the strategy will have to be developed in a context of severe financial restraints. Any new orientations, apart from collaboration with partners, will be achieved primarily by internal redeployment, providing the corresponding training where necessary. Development of the department's activities will also involve acquiring new contractual resources.

Development-oriented targeted research

The title of this section defines CIRAD's overall mandate; this mandate is completed by the July 1996 contract of objectives which requires that it "promote rural development to satisfy the increasing needs of populations". For CIRAD-CP, a concern for sustainable development in a conserved environment more particularly needs to be combined with this rural development objective, due to the prolonged cultivation period of the plants involved.

The tree crops that fall within the expertise of CIRAD-CP are primarily grown (with the exception of oil palm) on smallholdings and it is therefore mostly towards that social group that the search for technical innovations needs to be directed as a priority.

Furthermore, the evolution of the international economic context is marked by market segmentation and development of the private sector, among other things. That means that different stakeholders are becoming involved, with greater intervention by large private companies in marketing and primary processing.

It is likely, in the very near future, that some of them will be playing a more decisive role in production than at present. New potential partners are therefore emerging who are interested in greater security of their supplies and likely to fund the research that is indispensable for maintaining an environment that is propitious to raw material production. This arrival of new partners is seen to be very important for CIRAD-CP insofar as States no longer fulfil their function in aiding development-oriented research. In the first analysis, research of more particular interest to the private sector involves different aspects of the commodity channels: agricultural research proper, seed distribution, post-harvest technologies, stakeholder coordination, training, etc. Establishing new types of cooperation with the private sector is all the more desirable in that a certain number of firms are French or are based in France.

Lastly, CIRAD-CP is also part of a French Research sector which, whilst not losing sight of the application aspects, must also carry out top-level fundamental research to explain biological phenomena at primordial stages of cellular and molecular functioning.

Organization by commodity channel

The organization principle adopted for the department is that of structuring by commodity channel programme. This principle denotes insertion on the international scene and stakeholder coordination as major targets for the department's operations.

The commodity channel programmes are based first and foremost on a systemic method of analysis, commodity channel analysis, whose specificity lies in the identification of interactions between all the elements in the chain linking products, processes and stakeholders in the channel, from production right up to final consumption[3].

The commodity channel, as a concrete economic and social reality, is used as the basis of a common language accessible to all. It comprises several elements:

▸ a physical entity (the product: cocoa, coffee, oil, latex, etc.), which undergoes a whole set of processes from its origin up to its final consumption, which leads on to an initial type of research questions concerning: characterization of condition, identification of processes, and quality control; a succession of natural processes (e.g. ripening) and procedures (technical intervention: drying, pressing, roasting, etc.), which are the basis of processing, and which give rise to other questions on the understanding of mechanisms, adaptation of processes and technical innovations;

▸ a set of stakeholders involved from the origin of the product up to its final consumption, with questions regarding the behaviour and specific objectives of stakeholders, mechanisms of adoption and definition of acceptability thresholds.

A commodity channel analysis helps in establishing a functioning model comprising the three axes (product/process/stakeholder) that function together and which, in practice, form a coherent whole. It identifies upstream-downstream and downstream-upstream information flow circulating within the system. There are several types of descriptors: volume, quality, costs, different types of stakeholder organization, etc. They may be reflected in internal competitiveness (within the commodity channel) and external competitiveness (with respect to other commodity channels or other consumption alternatives).

---

3 A more detailed definition is given in Notes et Documents, No. 24, entitled "Le concept de filière: un outil pour la recherche".

The commodity channel analysis is used to express the requirements of the various stakeholders and to examine their overall coherence. It can also bring out the technical, economic or social constraints that act as limiting factors in commodity channel functioning, along with unexploited potential. Identification of the constraints and areas of potential can then be expressed in terms of research requirements, listed in order, either of priority or succession in time. Commodity channel analysis thus provides valuable assistance for scientific programming.

However, organization by commodity channel should not be allowed to hide the fact that all the crops are integrated into an overall farming system and that creation of tools cannot be considered separately and independently, i.e. without considering the consequences of their use for all the crops in the farm's production system. It is necessary to complete the strictly commodity channel approach with steps that take into account the farm and its environment.

Lastly, the commodity channel programmes rely on all agricultural research disciplines for developing their diagnoses and research. Hence, strategic choices have to be analysed bearing in mind the different scientific disciplines involved.

In a commodity channel, the issues are usually expressed in terms of competitiveness, based on characteristics associated with volume, quality and costs, along with geographical and social considerations. The answers required are therefore rarely to do with disciplines alone, or even the result of several disciplines combined. Establishing a diagnosis, drawing up research projects and conducting such research require strong and ongoing interaction between researchers working in numerous disciplines, be they agricultural or social. Moreover, the expected results are not only the creation of innovations, but also their adoption by stakeholders in the commodity channel. Thus, it is not the maximum solutions, nor the optimum solutions, that are sought as a priority, but primarily "acceptable" solutions. For that, it is essential to maintain an ongoing dialogue between researchers and users of research results, to ensure the application of such results. Indeed, the lessons of the past show that the development of "acceptable" solutions can only occur through a continuous iterative process between research and users.

Whilst researchers need to be able to benefit from the most up-to-date scientific environment possible in their respective disciplinary fields, they also need to be confronted on a continuous basis with the realities faced by operators in the field. Whilst improving scientific knowledge in the fields covered is important, it remains secondary.

Lastly, choosing to maintain a structure by commodity channel makes it possible to preserve overall sector expertise, replenished by ongoing research activities, which is one of the department's major assets. That does not necessarily mean developing research in all the fields covered by the commodity channel, but it does mean being directly involved in providing answers to some of the strategic challenges facing it.

CIRAD-CP choices

The department's first concern, when meeting the previously analysed specific challenges facing tree crops, will be to take on board social sciences, not only to take into account the strategies of stakeholders in the commodity channel, but also to deal with the central issue of farming system agro-economic sustainability, the answers to which go largely beyond the technical framework. It will therefore be necessary to consider all aspects, be they agronomic, ecological, economic, social or political. One of the most immediate examples is replanting.

In the social sciences field, the department's strengths are virtually nil and research will be organized with back-up from the TERA department and from the "Economics, Policies and Markets" programme of the AMIS department. However, the department will not be able to remain without skills in Economics and Sociology. In order to ensure true partnerships, the department will have to acquire skills in commodity channel analysis and acquire the services of several agricultural economists. It is therefore in those fields that priority should be given to staff recruitment.

In terms of thematic research, improving productivity primarily means management and exploitation of biodiversity, crop protection, and plot agronomy. It also involves studies of post-harvest operations and primary processing.

As regards the exploitation of biodiversity, the department intends to preserve its variety creation skills for each of the plants under its mandate, and maintain its role in managing reciprocal recurrent selection schemes, as that remains the most effective methodology for perennial plants. Molecular biology will remain an important tool, which should open up the way for marker assisted selection in the near future. Somatic embryogenesis will also remain a major subject, because, although there has been no direct commercial exploitation, it opens up the way for genetic engineering and an explanation of the physiological mechanisms involved in plant functioning.

However, conventional breeding work needs to go hand in hand with close coordination between molecular geneticists and breeding geneticists, and between geneticists and other disciplines, particularly crop protection and agronomy. Managing operations by inter-disciplinary commodity channel projects will promote the integration of these different components in joint enterprises.

On the other hand, the department also possesses more all-round tree crop breeding skills; particularly in the areas of genetic resources management, database use and quantitative genetics. This is a field of scientific excellence representing a specificity which the department intends to strengthen and promote as a focal point in the future overall agricultural research system.

Crop protection is a key area for tree crops and its importance is increasing with time. The massive increase in cultivated areas, combined with very long cultivation cycles, encourages the emergence and multiplication of diseases and pests.

Nevertheless, it will not be possible to develop research on all the problems encountered, so a choice will be made. For cocoa and rubber, two major diseases that lie behind limiting factors will be concentrated on: cocoa black pod and South American leaf blight respectively. Studies on coffee berry disease and vascular wilt will be continued or launched. For oil palm, the priority disease remains bud rot, to which a solution would provide an "open door" to Latin America. Lastly, developing an effective control against lethal yellowing is a major challenge to the survival of the coconut sector. Just one special project will be developed to control a specific pest - the coffee berry borer. However, problems caused by other insect pests will be taken into account within studies of the different production systems. Nevertheless, the absence of research directly geared towards a subject as important as cocoa mirids raises a real problem.

Generally speaking, the search for sustainable genetic resistance will be favoured and incorporated into an overall integrated control context. Indeed, new molecular tools and genetic modification offer possibilities of making substantial progress in this field. Skills will need to be strengthened in the corresponding disciplines, in order to cope with ever increasing demand.

In agronomy terms, whilst the department has undergone substantial erosion of its general agronomy skills (environmental factors and conditions, crop techniques, planting expertise), a large proportion of staff still remains in that field, though the average age of the researchers is quite old. On the other hand, the numbers involved in studies of plant and crop stand functioning remain small (though with a lower average age), whereas this is one of the department's strong points, which needs to be further strengthened, particularly for establishing decision-making models, including the effects of crop management sequences on yield elaboration. The department is therefore planning to gradually switch its available agronomy forces to this pole, by replacing retiring general agronomists with agronomists/ecophysiologists. With such an approach, it will be necessary to consider both the farm and the economic constraints, hence it will be necessary to acquire a significant degree of skill in agricultural economics and to set up a training scheme for generalist-plant experts taken from the pool of specialists who already have several years of practical experience.

Quality remains the main topic for chemistry and technology (characterization, analysis, determinants, etc.). Indeed, current political and economic developments are making quality one of the decisive stakes for the coming years.

From the producing country angle, quality control checks by state institutions are on the way out, and the department will seek to work with new partners, in the private or semi-public sectors, in order to put its know-how to optimum use. However, the department's ambitions go beyond the strict field of characterization and control, since quality is the result of many factors, from variety to post-harvest processing, and it is the entire quality chain that needs to be understood. To that end, it will be necessary to step up field activities for post-harvest processing operations in the smallholder environment. Furthermore, from a consumer country angle, there is a strong tendency towards increased demand for quality, at least for agricultural food products, for "taste" reasons but also for all aspects of food safety (pesticide residues, mycotoxins).

Complementarity to be sought within CIRAD

There are many points in common between the activities engaged in by the department and the different thematic programmes of the AMIS department, and practically all the CP projects will require scientific and methodological back-up. New circuits need to be opened up through contractual arrangements in line with the changes in researcher assignments between the two departments. However, their introduction should not lead to any major changes in the type of research conducted compared to the previous situations.

The department also proposes to develop more innovative fields of action, and particularly to strive for a new contractual agriculture by playing a greater role than it has in the past in bringing to producers the innovations it helps to create.

This approach, which is partially new at CIRAD-CP, requires skills and human resources that the department largely lacks. In order to take on this transversal approach to farm functioning problems, the arrangements for cooperation between researchers in different CIRAD structures working in the same geographical situations need to be simplified. In practice, that will mean consultation when organizing research activities to be carried out under the tree crop commodity channel programmes and those of the "Humid Tropics" (HT) and "Smallholder Farming" (SF) programmes, so that the outcome will be field projects in which all are jointly involved.

The HT programme organizes its operations along two main lines: regional development issues and farming system sustainability. Thus, at first glance, collaboration with the HT programme will concentrate on the following themes:

▸knowledge of the agricultural environment, farm typologies,

▸knowledge of crop management sequences, interventions within those crop management sequences, development of transferrable innovations, action-research approach,

▸ drafting and dissemination of technical information,

▸production of regional overviews.

The "Smallholder Farming" programme, whose research concentrates on family farms, agricultural organizations, product utilization and local development would be particularly involved in:

▸ the choice of sites,

▸ land studies, with:
- .economic management of farms and stakeholder strategies,
- .land occupation issues,
- .smallholder organizations and professional structuring,
- .primary processing.

▸ production of overviews.

Depending on whether the cropping system, farming system or the farm environment is considered, other programmes may be involved and called in for their support, or jointly with CP, HT and SF, and notably the "Agrosystems Management" (CA department), and "Land and resources" (TERA department) programmes, along with the AMIS department's "Economics, Policies and Markets" and "Agri-food Systems" programmes.

Partnerships to be renewed

The department needs to reconsider its policy of collaboration with the national and international scientific community.

With the other French research centres, relations with ORSTOM go back a long way and have been fruitful in the genetic resources and biotechnology fields; they undoubtedly need to be redefined, but in terms of more effective integration and development of joint operations. New relations also need to be sought with INRA in numerous fields, in order to strengthen scientific potential, particularly for marker-assisted selection, plant growth and production modelling, along with farm economics. Closer relations will have to be established with other organizations within the Montpellier agricultural research pole.

On an international level, for conventional bilateral approaches, scientific rapprochement and partnerships should be established under contract with national institutions playing a major role in research on the plants that concern CIRAD-CP (Malaysia for rubber, Colombia and Brazil for coffee, etc.), and exchanges with the Ivory Coast should be rationalized. On a European scale, a particular effort should be made to promote the department's operations. Initially, the operations of BUROTROP (Bureau for the development of research on tropical perennial oil crops) should be revived, then the possibilities of setting up similar structures for the other plants should be explored.

However, it is in the multilateral international cooperation environment that the greatest changes can be expected in the coming years. In the 70s and 80s, the main problem tackled by the international agricultural research system (represented by CGIAR) was food self-sufficiency. That has now been joined by concerns about reducing poverty and ensuring sustainable management. The introduction of these new challenges has led the international system to take a closer interest in export tree crops and CIRAD-CP, which is the only research institute that deals specifically with tree crops, is in a focal position that must be strongly defended. It is essential to ensure that its presence is acknowledged and to pay attention to the establishment of institutions that will be accompanying globalization (NARS group, Global Forum).

Lastly, as already mentioned, collaboration with the private sector also needs to be revised in a context of company commitments to production, which could also go hand in hand with part-funding of research and development efforts. Indeed, whilst the number of European plantation companies is continuing to decrease, the major multinationals are genuinely concerned about guaranteeing their supplies. These concerns are reflected in their will to become more deeply involved (either individually or in associations) in the means of production and marketing. However, these groups do not wish, at least for the time being, to become directly involved in production itself, and need partners to manage research programmes in the field or to act as middlemen with development operators. Given its acknowledged field skills, and its overall commodity channel expertise, CIRAD-CP is already called upon and ought to be able to play a major role at this level. It is therefore necessary to clarify what operations could be proposed to such partners and to more effectively advertise their existence to the professionals.

Overseas installations

As CIRAD-CP was unable to set up its own bases, either under full ownership or on a long-lease basis, during the last Five Year Plan, the external review suggested identifying target-countries (one per continent), in which the department could concentrate substantial resources and operate in the chosen country and the sub-region. This proposal seems attractive for avoiding excessive geographical dispersal and for bringing together at nearby sites the critical mass required for effective research operations. However, such a strategy is difficult to implement, firstly because past lessons tend to incite towards minimizing political risks by developing diversified structures, and because there is sometimes strong competition between neighbouring countries and the choice of a particular country may be difficult and frowned upon by the other States, and, lastly, because it requires investments that currently outweigh the department's possibilities.

Nevertheless, CIRAD-CP feels that it is essential to maintain close ties with the field by assigning a large number of its agents to producing countries, based on specific contractual programmes drawn up with the host structures. In order to avoid excessive dispersal, it will endeavour wherever possible to concentrate its ongoing operations in a few countries that are important for its activities. For example, Indonesia and the Ivory Coast seem to be suitable sites for installations covering all its commodity channels. For other countries, decisions will be taken with reference to an analysis table taking into account:

- production, which may be that of a major country or may have decisive weight in the GNP,
- a production particularity (fine cocoa or quality coffee),
- the scientific strategy (access to a collection, a laboratory, a network, etc.),
- a financial opportunity,
- the geopolitical strategy of the back-stop ministries and the EU,

- the host structure,
- the presence of other agents from the department or other parts of CIRAD,
- rapid communication possibilities.

However, it is by taking part in networks that the department has been most innovative in recent years, whether it was the founding force as for the oil palm breeding experimental design and INGENIC (cocoa), or a major participant as for the COGENT (coconut) and RECA (coffee) networks. It is in this field that the department will probably find the largest number of opportunities for renewing its overseas operations, notably by keeping careful track of developments in the international agricultural research system and of the place that will be accorded to tree crops.

THE SCIENTIFIC PROJECT

The department is organized into five commodity channel programmes: cocoa, coffee, coconut, rubber and oil palm. The programmes incorporate a certain number of projects, which consist of research operations representing the basic activities entrusted to a researcher. Projects are multi-disciplinary and are an operational expression of the scientific activities of the department's researchers.

Other departments may be associated with the projects, especially through scientific support programmes and ecoregional programmes. This eventuality will take the form of proposals presented by at least one project per programme drawn up jointly with the "Humid Tropics" and "Smallholder Farming" programmes of the TERA department. These two programmes provide the skills that the department does not possess for studying a smallholding and its environment.

Research programming within each programme is presented in five parts, based on the same principles as those used to define the department's major trends:

- commodity channel characteristics,
- challenges and issues for research,
- the current situation: assets and skills,
- the programme strategy,
- the projects.

In addition, a "genetic resources management and use" activity common to the five programmes will be introduced. Databases will be established for each of the plants, so as to gather and utilize available information, such as morphological and molecular characteristics, but also agronomic values.

Additional information on the assets of the programmes and an analysis of the department's fields of expertise can be found in the annex.

The Cocoa Programme

Characteristics of the commodity channel

Cocoa is a cash crop produced throughout the humid Tropics and accounts for 3 billion US dollars' worth of trade each year (1995 figure).

With over 2,800,000 tonnes in 1995/1996, world production has surged over the last few years, though it eased off slightly for the 1996/1997 harvest. Consumption is clearly on the up, with increased consumption of chocolate products and the emergence of new markets in eastern Europe and Asia. Most forecasts expect a production shortfall in the coming years.

Africa holds a leading place at 65%, with 40% for the Ivory Coast, and an increasing share for Ghana, which has become the world's second largest producer. In America, countries that were large producers in the past are now mostly small producers, which stand out with their production of fine cocoa. Brazilian cocoa cultivation is faced with the witches' broom problem and is set to see its production drop to 150,000 tonnes in 1997. In Asia, following a very rapid rise in yields, the areas planted are decreasing and yields are dropping in Malaysia, and there is a degree of stagnation in Indonesia.

Production structures differ depending on the continent. In Africa, most production comes from smallholdings (under 5 ha). In Ecuador and Brazil, large estates predominate. In Asia, the two sectors are similar in size.

The size of smallholdings is determined by access to land and the ability to secure labour. Plantations are traditionally set up on newly cleared forest land. The generally extensive cultivation is integrated into complex farming systems. Yields per hectare are often low due to strong parasite pressure and ageing plantings. Transfer of technical innovations is not always satisfactory.

A deep and rapid change is taking place in the socio-economic environment following liberalization of the commodity channel in African producing countries, resulting in the emergence of producer organizations and decentralization of processing facilities to the production sites. Increasing vertical integration is also observed.

In the research field, operations covered by National Research Institutions in the producing countries are declining due to a lack of operating resources. Private research is carried out by industrialists and mainly concentrates on end product manufacturing processes. Public research operations carried out in developed countries are, with the exception of CIRAD's, undertaken by small isolated teams. Lastly, in the absence of any organized research network, the research efforts of the different operators are dispersed.

Challenges and issues for research

Adapting supply to demand, in terms of volume and quantity, is a major challenge for the coming years. Faced with increasing demand, it is not very feasible to increase the areas planted due to limited forest availability, and it will therefore be necessary to promote intensified cocoa cultivation, whilst maintaining the current areas. With competition from other crops, stabilization of the areas planted will depend on the competitiveness of cocoa cultivation.

In order to respond to the increasing demand from users and to market segmentation, the quality (consistency and quality proper) of the product will take on major importance, for flavour cocoas and for bulk cocoas.

To achieve these objectives, priority should be given to four main challenges:

Crop sedentarization, which means improving production sustainability through adapted varieties and cost-effective crop management sequences, but also the renewal of ageing plantings, with methods that are acceptable to growers and guarantee that yields are maintained.

Parasite pressure, which is the main limiting factor for cocoa production, the main pests and diseases being:

- black pod rot, which occurs worldwide,

- mirids, which are found on every continent, though particularly in Africa,

-witches' broom in the Amazon basin,

- the pod borer in Southeast Asia,

and
- watery pod rot in Central America,

- swollen shoot in Ghana and Togo,

- thrips.

The challenge here is to develop more resistant varieties more suited to local conditions, and development of effective integrated control methods.

The socio-economic structuring of the commodity channel seems to be decisive in the liberalization context, which leads to State withdrawal and greater involvement of private firms in production. Faced with a degree of production instability, which exacerbates competition, greater flexibility is required.
The beginnings of a structuring into smallholder organizations have been seen, in order to adapt to the new situation and to attenuate the inadequate supervisory structures. Analysis of farming

systems, innovation transfer and sociological factors involved in the change will provide a clearer understanding of commodity channel trends and help in decision-making in the production zones.

Control of quality chains in the major cocoa growing zones is necessary for improving a given cocoa and to meet more diversified customer requirements. This means improving and organizing post-harvest processing and acquiring knowledge of how the farming environment and processing techniques affect the flavour composition of cocoas.

Market segmentation is generating particular interest in fine and flavour cocoas. This development calls for specific research work in the fields of variety improvement, technology and famer supervision.

The current situation: assets, skills

CIRAD is the only research centre of the industrialized nations that has a team of researchers covering all the disciplines of the cocoa commodity channel, from variety improvement to end product processing.

The main strengths of the cocoa programme lie in:

▸ Substantial investment in genetic diversity studies and acquiring knowledge of the cocoa tree genome (in conjunction with the BIOTROP laboratory). A considerable effort has been devoted to the search for molecular markers (a genetic map of the cocoa tree with 400 markers is available).

▸ Genetic improvement work, with parent assessments and the selection of new, higher-yielding hybrids with greater resistance to *Phytophthora*, by means of the experimental design that existed in the Ivory Coast, working jointly with IDEFOR.

▸ Strong mobilization against black pod rot, with the CAOBISCO (European Chocolate Manufacturers' Association) project, which brings together researchers from Cameroon, the Ivory Coast, Trinidad and France. Results are available on pathogen diversity and assessment of varietal resistance. Another approach involves identifying areas of the genome involved in resistance.

▸ Joint work with INRA to develop a method of inoculating viral particles, to assess Swollen Shoot resistance.

▸ Development of a hot fogging technique against mirids.

▸ Significant progress has been made in the flavour field, on the use of precursors and identification of aromatic compounds at different stages of post-harvest processing. These results help in producing specific flavours.

▸ Acquisition of knowledge on the effects of varietal origin and on the genetic determinism of technological quality traits, especially for the fine cocoas of America.

▸ Close cooperation with the LMGC laboratory at the University of Montpellier II, on the modelling of energy transfers in cocoa beans during post-harvest processing. The aim is to open up possibilities for technical innovations in bean fermentation and drying.

However, to obtain significant results, the programme will need to strengthen some of its skills (e.g. in entomology and social sciences), through redeployment or recruitment and by establishing formal collaboration with the scientific support programmes of the TERA department.

Programme strategy and research topics

In line with external review recommendations, the challenges facing the cocoa commodity channel, the programme's assets and the resources already available or feasible, four major fields have been adopted:

▸ A search for ways of improving the sustainability of cocoa-based farming systems, particularly in the major African production basin: Ivory Coast, Ghana, Togo, Cameroon, and Sao Tomé.

The work, which is relative to the productivity of cocoa-based farming systems, will need to tackle development issues on a farm scale, and an ecoregional scale under natural production conditions (Poto Project-Sao Tomé, Ets Touton and IDEFOR-Ivory Coast).

Studies of the socio-economic environment in the sector are of major importance for proposing farm modernization methods. With support from the TERA programmes, in the Ivory Coast and Sao Tomé, particular emphasis will be placed on studying the competitiveness of cocoa cultivation, innovation transfer and changes in the structuring of smallholder organizations.

Plant functioning, ecophysiology and soil fertility will have to be studied to determine appropriate crop management sequences, especially for replanting, regeneration and crop rotation.

Within these crop management sequences, plant-pest interactions will have to be examined and the hot fogging technique will need to be consolidated, in order to reduce parasite pressure, particularly from mirids; for Swollen Shoot, development of early tests should make it possible to steer varietal selection in Ghana and Togo. Back-up will be sought from the "Crop Protection" programme of the AMIS department and from INRA and the University of Strasbourg.

Germplasm exploitation and the population improvement programme in the Ivory Coast, under the IPGRI-CFC-ICCO project, should lead to the creation and selection of improved parents and varieties.

▸ Research on controlling black pod rot will be continued, with a view to achieving varietal tolerance, which the recent genome analysis results suggest is possible.

This operation primarily relies on action funded by the European chocolate manufacturers' association (CAOBISCO), in Cameroon, the Ivory Coast and Trinidad, and also with back-up from trials conducted in Papua New Guinea and Vanuatu.

The main trends will be geared towards improving varietal resistance, with a study of molecular markers of resistance; use of early tests correlated to field results to steer selection, and towards chemical control to deal with emergencies.

▸ A revival of cocoa cultivation geared towards top-quality products, in American countries that were formerly renowned for those criteria, should both enable potential fine cocoa producers to regain their place on the world market and consumers of fine cocoas to secure the supplies they need.

The European Union project currently being implemented with Ecuador (INIAP) could be stepped up and extended to issues raised by Venezuela (FONAIAP). Other similar operations could be considered in the Caribbean and Mexico. They incorporate a study of diversity in certain populations, such as wild Guianan materials, the "Nacionals" of Ecuador and Criollos of America. A programme to improve the agronomic characteristics of selected fine cocoa clones will be drawn up, particularly to increase resistance to witches' broom, with the potential existing in French Guiana (CIRAD) and in Trinidad (CRU).

Emphasis will be placed on dissemination and replanting in the smallholder sector and on post-harvest processing and the structuring of smallholder organizations and marketing networks.

▸ Definition of flavour potentials, from variety and *terroir*, up to ultimate product processing, will primarily be intended to distinguish between different high-quality specialty cocoas (collaboration with Barry-Callebaut).

Agronomic aspects of the elaboration of bean composition and its relations with use qualities will be studied. The results obtained will be applied through the introduction of a "guaranteed origin label" (Valrhona Operation-Venezuela).
An understanding of how flavours form will open the way for innovative solutions, in terms of varietal selection and technology, to simplify the work of operators and reduce production costs, while mastering quality (LMGC and Ferrero).

Research projects

Four research projects are proposed:

① **Sustainability of cocoa-based farming systems in Africa**

With 65% of world production, Africa is the most important cocoa growing zone. It primarily consists of smallholdings (under 5 ha), usually set up on newly cleared forest land. Faced with increasing demand and limited forest availability, it is becoming essential to sedentarize cocoa cultivation, which means improving the sustainability of production and renewing the ageing plantings.

If that is to be done, a clearer understanding of the socio-economic conditions of production will be required.

② **Integrated control of cocoa tree *Phytophthora* rot diseases**

Black pod rot, which is caused by several *Phytophthora* species, is found throughout all the production zones. In Cameroon, losses due to *P. megakarya* exceed 50% of production. The epidemic is currently moving westwards and is threatening the Ivory Coast.

So far, application of chemical control methods has given few results. Eventually, the most desirable solution will be variety selection, which should make it possible to propose varieties with good resistance to *Phytophthora*. It will then be possible to put forward proposals for the introduction of genuine integrated control.

③ Revival of fine cocoa cultivation in America

The importance of fine and flavour cocoas, such as Criollos and Nacional, has declined over time, for two essential reasons: inadequate yields and high susceptibility to diseases, particularly watery pod rod and witches' broom. For those reasons, they have gradually been replaced by Trinitario type cocoas, which are less flavoursome, but hardier and higher yielding.

Moreover, post-harvest processing, on which end product quality largely depends, does not always seem suitable for the type of cocoa harvested.

This situation has led to a loss of genetic diversity and a shortage of fine and flavour cocoas, whereas demand from chocolate manufacturers is currently on the increase.

It is therefore necessary to develop a project for the selection and dissemination of fine cocoas with greater resistance to biological aggressors, to adapt post-harvest processes and to bring this about through the structuring of smallholder organizations and marketing networks.

④ Familiarization with and control of quality chains

Market segmentation is leading to a demand for cocoas of different qualities, from bulk cocoas to fine cocoas. However, in all cases, more consistent quantities and qualities are being sought in the downstream sectors of the commodity channel.

In order to assess cocoas, steer processing operations and introduce innovative techniques, it is essential to know how flavours form from harvesting to the roasted product.

The advent of chocolates made from "pure origin" cocoas will require perfect knowledge of the influence exerted on the end product by the *terroir*, by the varieties, by the growing methods and by primary processing.

Definition and mastery of specific crop management sequences will make it possible to meet the demands of processors, whilst providing growers with outlets under the best possible conditions.

Cocoa Programme

CHALLENGE	ISSUES FOR RESEARCH	PROJECTS
▸ Securing supply by sedentarization and intensification	.Improve the competitiveness of cocoa cultivation .Improve plantation sustainability. .Familiarization with yield components. .Provide adapted varieties. .Propose acceptable techniques for planting renewal.	**1- Sustainability of cocoa-based farming systems in Africa.**
▸Reducing the effects of parasite pressure	.Breed resistant varieties. .Develop integrated control methods against black pod rot, witches' broom and mirids.	**2- Integrated control of cocoa tree *Phytophthora* rot diseases.**
▸ Structuring the cocoa commodity channel	.Ascertain cocoa market trends. .Manage production zones. .Analyse farming systems .Develop smallholder organizations. .Improve innovation transfers.	**3- Revival of fine cocoa cultivation in America.**
▸ Controlling quality and its variability	. Determine cocoa quality factors. . Master primary processing. . Develop fine cocoa production. . Acquire an understanding of flavour formation and composition.	**4- Familiarization with and control of quality chains.**

Coffee Programme

Commodity channel characteristics

Coffee is a major source of currency for a large number of producing countries. The coffee trade generates between 9 and 15 billion dollars depending on the seasons and world prices, which can vary very rapidly. Around 40 to 80% of that total is redistributed to smallholders.

For a large number of families, coffee production remains an essential crop, and is often the main cash resource. Apart from these socio-economic assets, coffee plantings must play a paramount role in protecting soils from erosion in zones with a high population density and/or hilly terrain.

Coffee, which is used almost exclusively for beverage purposes, comes from the cultivation of two coffee species, Arabica and Robusta, planted on around 11 million hectares, and currently producing almost 6 million tonnes worldwide (100 million 60-kg bags). Each of the types of coffee tree is grown in a specific ecology:Arabica is an altitude coffee, whereas Robusta develops in low-lying equatorial zones.

Of some 5.5 million farms growing coffee, 85% cultivate under five hectares of coffee trees, primarily using relatively unskilled family labour. 90% of Robusta cultivation is extensive (50%) or semi-intensive, whereas Arabica cultivation is mainly practised on a semi-intensive (65%) to intensive (20%) basis.

Arabica accounts for around 70% of world production, but over the last ten years or so production has stagnated or even declined. On the other hand, Robusta production is increasing, notably through rising production in Asia (Indonesia, Vietnam, etc.) and Brazil; such development over recent years can be explained by the specific use of Robusta, particularly for instant coffee, but also because it is economically more affordable for a large number of consumers. Brazil, with more than 25% of world production and annual production variations due particularly to climatic conditions, seems to be an essential driving force in the supply:demand ratio.

Despite its current sluggishness, demand has continued to grow steadily over the last ten years; a slight shortfall is recorded, due to Arabica production (supply:demand = 0.96), which is what lies behind the currently high Arabica/Robusta price differential.

Extension of Robusta cultivation is still possible in potentially available forest areas, virgin lands or low population zones, such as in Central Africa. Nevertheless, planting in forest zones leads to ecological changes on a plot and regional scale: modification of the flora, changes in soil and climate, disease and pest development, which combine with the degradation of older plantings to reduce yields and increase labour and input requirements.

For Arabica, whose production is stable or in slight decline, extensions are highly limited outside marginal zones and land occupation pressure is generally high. Furthermore, as Arabica is a mountain crop, erosion problems remain considerable if crop management sequences are inappropriate. Intensification of Arabica monoculture leads to a change in the chemical, physical and biological composition of soils.

The international coffee market is characterized by a speculative trait that causes world price fluctuations, so that producers have difficulty maintaining the profitability of their crop. This difficulty is exacerbated by three major constraints encountered in coffee cultivation:

- labour-intensiveness (increasingly expensive, increasingly unavailable): for planting upkeep, but especially harvesting (around 50% of the total), which is difficult to mechanize for quality reasons, the farm structure and the topography,
- high susceptibility to diseases (Arabica coffee berry disease, leaf rust, vascular wilt), pests (especially coffee berry borers) and nematodes,
- weak development of agricultural professional organizations compared to the accelerating liberalization of the commodity channel (changes in agricultural policies).

Lastly, current development of the market for specialty coffees (gourmet coffees, *terroir* coffees, "organic" coffee) is providing a new opportunity for producers.

Challenges and issues for research

For consumers, demand involves 3 basic points:

- the possibility of purchasing coffee at a reasonable price,
- having access to coffee of standard quality without any off-tastes and without consumption risks (consideration of safety/toxins),
- increasing demand from a "special or fine" coffee market.

For importers and roasters, the response to consumer demand involves:

- maintaining the quantity and quality of guaranteed origin coffee supplies for blends, and specialty coffee supplies,
- eliminating heterogeneity between batches and toxin problems.

For producers, the constraints of coffee cultivation and of the market, which is characterized by world price fluctuations, mean that open-ended crop management sequences have to be available that improve farm profitability (reduction in the cost price of coffee at the production level) and ensure stable agricultural income. That means rational intensification based on sustainable management of natural and agronomic resources, along with optimum use of inputs enabling sustainable, environment-friendly production. Environmental protection pressure is on the increase from consumers (food security) and local and international bodies:

- urgent need to reduce contamination of water tables and water courses by post-harvest processing and use of agri-chemicals

- consideration of the importance of shaded coffee trees as artificial forest and as a factor in conserving natural forests (shade trees can be used as a source of firewood, etc.).

The need for rational intensification is felt in different ways in the coffee commodity channel depending on the species cultivated:

- for *Robusta cultivation*, which is mainly practised on an extensive basis, there is a need to *improve productivity and cost-effectiveness in smallholdings, which are mostly degraded and old,*
- for *Arabica cultivation,* which is mainly practised on a semi-intensive to intensive basis, there is a need to *maintain productivity and improve cost-effectiveness by proposing sustainable farming systems.*

Meeting this cropping system productivity and sustainability challenge will necessarily mean *integrated management of the major pests and diseases.*

In order to face these major challenges in coffee cultivation, the research conducted needs to be geared towards:

Knowledge of the farm and its environment: knowledge of the economic and social components of farms is paramount for understanding the logic of farm functioning and the objectives and strategies of the farmers. This is essential for designing appropriate farming systems integrating a maximum number of technical innovations and transferring them to coffee growers.

Exploitation of biodiversity:

In *C. arabica*, the extremely narrow genetic base of currently cultivated varieties and their high susceptibility to biological aggressors necessitates the development of hybrids using wild Ethiopian genotypes. The material created is to be propagated *in vitro.*

In *C. canephora*, exploitation of the genetic diversity discovered jointly with ORSTOM involves the creation of improved populations, whose dissemination by seed will be more accessible to growers than clones distributed as cuttings.

Exploitation of genetic diversity will also involve the development of new breeding tools (genetic modification and development of marker-assisted selection) for which the first results are promising.

Development of parasite pressure management methods:

- use of material resistant to biological aggressors, with rational management of such resistance. That will involve characterization of the resistance and a study of variability in the biological aggressors,
- introduction of crop management sequences specific to the ecosystem in question,
- optimization and reduction of chemical control,
- development of new pest control tools (trapping, etc.),
- development and use of early warning tools.

Fertility management and plantation functioning: in view of ecological changes caused by an intensification of coffee cultivation (planting degradation, etc.), often practised in fragile environments (mountain crop, volcanic soils, etc.), combined with the introduction of new integrated control practices, new crop management sequences will have to be developed and geared towards:

- restoration and/or sustainable management of soil fertility in coffee monocultures or coffee-based farming systems.
- development of farming systems adapted to newly created varieties (FA hybrids propagated *in vitro*, transgenic plants, etc),
- adaptation of cropping practices to be given priority according to the economic context (mechanization to back up manual harvesting in intensive coffee cultivation, organic coffee, etc.)
- characterization of factors that determine yield elaboration in various farming systems and under different soil and climatic conditions.

Assessment and characterization of quality: faced with the demand for coffee with a minimum number of physical defects, a total absence of off-tastes and contamination by toxic compounds (OTA = Ochratoxin A, etc.), and with the current development of guaranteed origin or *terroir* coffees, research activities need to be developed on:

- gourmet coffees - *terroir* coffees (Arabica and Robusta), *terroir* delimitation and characterization of origins,
- effect of cultural practices, varieties and post-harvest processing (Arabica and Robusta) and conditions for mycotoxin development,
- improvement of wet processing (Arabica and demand for mild altitude Robusta in Uganda, Brazil and Laos, etc) and conditions for limiting water consumption (in view of pollution risks).

Current situation: assets and skills

To meet these challenges, the coffee programme has knowledge acquired in close partnerships with operators in the coffee commodity channel in producing and consumer countries, which will enable it to implement the lines of research identified.

In the genetic resources and variety improvement fields, progress has been substantial for *C.arabica* with the evaluation of Ethiopian origins, notably for their resistance to pests and diseases, which are being used to create F1 hybrids. Close collaboration with BIOTROP has made it possible to master somatic embryogenesis of these F1 hybrids and commercial distribution can be considered, subject to mastering their adaptation in the field. For the *canephora* species, reciprocal recurrent selection has enabled more effective exploitation of the species' diversity and major genetic progress has been achieved with the selection of high-yielding hybrid varieties. Their distribution in seed form makes them more accessible to smallholders than clones.

Access to genetic resources in the 2 breeding poles, at CATIE in Central America and IDEFOR in the Ivory Coast, is one of the coffee programme's essential assets.

Work developed in a partnership with NESTLE since 1994 has led to success in the genetic modification technique (BT genes against the leaf miner), which can now be extended to the search for cultivars with resistance to major pests (coffee berry borer).

With the knowledge acquired about the coffee berry borer (population dynamics, biological control) it is now possible to orient control towards the use of complementary methods, such as localized chemical control and trapping, and to issue agricultural early warnings.

Significant progress has been made on understanding the parasite mechanisms of the main genera of nematodes (*Meloidogyne* and *Pratylenchus*) on coffee trees in Central America. Characterization of the nematode fauna has revealed the existence of considerable diversity in the populations and confirmed the danger of certain pathotypes for Arabica coffee cultivation, which will have major consequences for resistant material breeding programmes. A resistant rootstock has already been created and its distribution launched.

Leaf rust epidemiology in Central America suggests that it can be controlled by an early warning system. The existence of partial resistance sources in wild Ethiopian material has been confirmed.

For *C. arabica* coffee berry disease (CBD), which is currently confined to the African continent, the variability of the pathogen is now better understood, notably through a project conducted in collaboration with Kenya, Cameroon and Portugal in connection with the RECA network. This is a prerequisite for further identification of resistance sources, which has begun, notably within the wild Ethiopian material.

Knowledge has recently be obtained about soil biology. The role of endomycorrhiza in plant development and nematode tolerance have been discovered, which will have consequences for the development of *in vitro* plantlet acclimatization procedures and for fertility management. Studies conducted on coffee-legume intercropping will make it possible to conserve soil fertility, while lowering input consumption. Moreover, a harvest estimation method has been developed.

Socio-economic studies on smallholdings have revealed the need to contribute towards the emergence of smallholder organizations, so as to propose technical solutions adapted to their constraints.

Lastly, chemical, biochemical and sensorial characterization of cup quality is an essential and specific skill of the CIRAD laboratory (e.g.: Robusta clones, Arabica hybrids, Riuru 11). These tools will be used to continue characterizing fine or *terroir* coffees and to enhance knowledge of how ecological factors, cultural practices, genotypes and post-harvest processing affect quality.

Programme strategy and research topics

In view of the challenges, assets and skills of the coffee programme, and of the issues raised for research in responding to this need for rational intensification, priority will be given to the following four fields of action:

- *Improvement of the productivity and cost-effectiveness of smallholdings mostly farmed on an extensive basis*

Operations will be mostly confined to West Africa, on Robusta-based plantations, notably in the Ivory Coast. The results will be applicable to Robusta plantations in East Africa and Asia and will provide a clearer understanding of the solutions to be found for *C. arabica* farming systems run on an extensive basis in Africa, Asia and the West Indies.

- *Development of sustainable farming systems to maintain productivity and improve the profitability of plantations mainly run on an intensive basis*

Operations will be carried out on intensified *C. arabica* farming systems in Central America. It will be possible to extend the results to similar plantations in Latin America, Brazil, East Africa and Asia and will provide a clearer understanding of the solutions to be found for intensive *C. canephora* plantations in Africa and Asia.

- *Integrated management of two coffee diseases: vascular wilt and Arabica coffee berry disease (CBD).*

The solutions to be found for these main two diseases affecting African coffee cultivation will be sought in East Africa. The results acquired in the CBD study are of paramount importance for Arabica cultivation throughout Latin America.

- *Integrated management of a major coffee pest worldwide: the coffee berry borer*

The solutions required for this pest, which affects coffee cultivation worldwide, will be developed in Central America and will be of paramount interest for all Arabica and Robusta producing countries.

This strategy relies on the strengthening of our operations with partners in West Africa and Central America, in order to have access to the genetic resources of two breeding poles, CATIE for Arabica and IDEFOR for Robusta, and also in East Africa, which is the zone in which quality coffee is produced in Africa and in which essential field partners, such as Kenya, are prominent requesters of cooperative action.

In order to implement this strategy, it will also be necessary to:

- develop our operations concerning *the agro-economic sustainability of farming systems.* That will mean stepping up our actions (through recruitment or redeployment of an agricultural economist) to acquire a greater understanding of yield components and of the economic and social factors of farms, so as to design and transfer to coffee growers the farming systems that suit their requirements. Collaboration with the SF and HT programmes of the TERA department will be decisive.

- continue the efforts currently being deployed in the use of molecular biology (transgenesis), which is being considered for the coffee berry borer. Use of marker assisted selection remains to be developed, in conjunction with ORSTOM, more particularly for CBD. Eventually, as our command of molecular tools expands, in close collaboration with the AMIS department and NESTLE, the way may be opened up for using genes of interest.

- maintain our comparative advantage in the field of assessing and characterizing quality, and remain in a position to take part in research in the field of food safety (mycotoxins), which is currently a major worry for processors and producers.

Given the extent of the operations to be developed on crop protection, and the Programme's current strengths in this sector, recruitment of a plant pathologist and an entomologist could be a priority. Likewise, for dealing with post-harvest processing problems (reconversion of wet processing, mycotoxins, etc.), to be covered in close collaboration with the TERA and AMIS departments, strengthening with a technology specialist seems necessary. These recruitments are felt to be essential for responding to requests from partners that cannot be taken into account in programming (Asia, South America, etc.), due to the Programme's current staffing levels, but which could be the springboard for developing new areas of cooperation.

Lastly, for coffee cultivation, a regional approach is indispensable. Our links with the PROMECAFE network in Central America and the RECA network in Africa, which are an essential tool for the Programme in developing new cooperation, will need to be strengthened.

Research projects

In line with the chosen fields of action and the skills possessed by the Coffee Programme, four multi-disciplinary projects are proposed. The project centred on extensive farming methods will be implemented in close collaboration with the HT and SF programmes of the TERA department. All the projects will require the expertise of the AMIS department or other scientific research centres (INRA, universities or institutes) for certain operations. The four projects envisaged are:

①- Improvement of *C. canephora* (robusta coffee)-based farming systems from West Africa

Most of the farms that grow coffee are smallholdings. The plantings are mostly old, cultivated on an extensive basis and are usually degraded; average yields per hectare do not exceed 250 kg of merchantable coffee. The limited technical skills of growers, mediocre soil fertility, parasitism and a lack of flexibility in the farming systems proposed all go some way to explaining such poor productivity, which is in contradiction with the potential of the planting material proposed by research.

Smallholders are having to cope with this situation in a context of limited access to inputs and rural credit (limited development of agricultural professional organizations compared to liberalization of the commodity channel, etc.). A particular aim is therefore to propose solutions for the rehabilitation of these plantings, with new hybrid planting material distributed in seed form which is more affordable for smallholders, and with crop management sequences adapted to that material in an intercropping context. Hand in hand with the emergence of smallholder organizations, an answer will have to be found to the quality problems encountered (problem with implementing the wet process, and mycotoxin development, etc.).

②- Sustainable exploitation of *C. arabica* in intensified farming systems in Central America

In this zone of high quality Arabica coffee production, most of the farms are run on a semi-intensive to intensive basis; Arabica cultivation on those farms has reached a generally high technical level and producer know-how is considerable. These plantations, which are often located in fragile environments (mountain crop, volcanic soils, etc.) and often produce more than 1 tonne/ha, suffer from considerable parasite pressure, exacerbated by the high susceptibility of the planting material and sometimes worsened by the intensive farming method. Faced with this situation, growers are obliged to develop new crop management sequences enabling sustainable exploitation of the agrosystem based on environmental conservation.

Continuing down an innovative avenue is therefore proposed: developing *C. arabica* hybrids, by using wild Ethiopian genotypes, which will be propagated *in vitro*. This approach will need to bear in mind the need to maintain optimum quality, particularly in view of the increasing presence of the countries in this zone on the fine coffees market. Utilization of these hybrids will be combined with the development of new crop management sequences, which will need to be geared towards sustainable management of soil fertility, and with the introduction of new practices for the integrated management of biological aggressors, to ensure sustainable resistance to biological aggressors in the new germplasm. Furthermore, in the current context of environmental conservation, reconversion of the wet process, to minimize water consumption, will be examined.

③- Improvement of coffee tree productivity in East Africa through management of the major phytosanitary constraints.

This project is intended to provide producers with various solutions for limiting the impact of two diseases on coffee tree productivity in East Africa:

- Tracheomycosis, which primarily affects Robusta, notably in Uganda and the Democratic Republic of Congo, and occasionally Arabica, particularly in Ethiopia. This vascular disease has taken on an endemic character and is currently destroying both estates and smallholdings.
- Coffee Berry Disease (CBD), which exists throughout the African Arabica growing zones. This disease can cause yield losses that can exceed 50% of harvests depending on the years and ecological conditions.
- The variegated coffee bug, which exists on both cultivated species of the *Coffea* genus.

The knowledge acquired under this project will make an essential contribution to activities at research centres in Latin America, which have incorporated into their programmes the search for resistant plants, notably to CBD, given the threat posed by these diseases for coffee cultivation worldwide.

Among the solutions likely to control these diseases, priority will be given to identifying resistant planting material validated for its intrinsic quality. A study will be made of pathogen variability and characterization of resistance mechanisms. A study on the effects of ecological conditions and of cultural practices on disease development will be a prerequisite for identifying crop management sequences capable of managing these diseases.

④- Genetic control and trapping to control coffee berry borer populations

The purpose of this project is to propose various and complementary solutions to growers for controlling populations of coffee berry borers in plantations. The coffee berry borer exists throughout the coffee growing zones worldwide and causes harvest losses (up to 25-30%) and also diminishes the quality of partially bored beans. Apart from its economic impact on production, severe infestation by the coffee berry borer jeopardizes supplies to the market in periods of production shortfalls, and therefore affects prices.

The demand for chemically untreated coffees is increasing and requires alternative, non-polluting methods. Control by using entomopathogenic fungi does not give very satisfactory results, neither does parasitoid release, which also costs more per hectare than chemical control. Other alternatives will be investigated:

- creation of resistant planting material, notably through identification of B.t. toxins and genetic modification,

- control by trapping, using allelochemical attractants.

Coffee Programme

CHALLENGES	ISSUES FOR RESEARCH	PROJECTS
▸ Improvement of extensive smallholding productivity and profitability (Robusta) ▸ Safety (toxins) and quality. ▸ Commodity channel organization	- Renovation / regeneration of degraded plantings (soils and planting material). - Obtaining hybrid seeds from improved populations. - Adaptation of cropping systems and post-harvesting processing methods. - Study of external and internal factors for quality.	**1- Improvement of *C. canephora* var. Robusta-based farming systems in West Africa.**
▸ Move towards rational intensification: maintaining productivity and improving the profitability of plantations mainly run on a semi-intensive basis (Arabica): - controlling parasite pressure, - maintaining quality. ▸ Positioning on the fine (*terroir*) coffees market. ▸ Sustainable exploitation of the agrosystem and environmental conservation.	-Enlargement and short-term use (breeding/crop management sequences) of genetic diversity against parasite problems and maintaining quality (F1 hybrids / IVC). - Development of new breeding tools (marker-assisted selection and genetic modification). - Characterization of fine/*terroir* coffees; study of external and internal factors for quality. - Soil fertility management. - Environmental conservation (pollution risks, etc.).	**2- Sustainable exploitation of *C. arabica* in intensified farming systems in Central America.**
- Management of two parasite constraints currently limited to coffee cultivation in East Africa: - Tracheomycosis (Robusta & Arabica), - Coffee Berry Disease on Arabica (CBD).	- Search for varietal resistance: . study of pathogens (characterization, variability). . Search for resistant material and early tests. - Effect of cultivation techniques and ecological conditions. - Use of resistant planting material. - Development of crop management sequences adapted to parasite management.	**3- Improvement of productivity in the coffee plantations of East Africa by managing the major phytosanitary constraints.**
- Managing populations of a major pest in the world of coffee cultivation: the coffee berry borer. - Reduction/optimization of chemical control use.	- Search for complementarity and synergy between various solutions for controlling coffee berry borer populations. . obtaining resistant material (genetic modification, etc.) . trapping: artificial traps, plant traps.	**4 -Genetic control and trapping for controlling coffee berry borer populations.**

The Coconut Programme

Commodity channel characteristics

Coconut, an intertropical palm, stands out from other tropical tree crops through its coastal and island ecology and its considerable hardiness. It withstands conditions considered to be marginal, such as very poor, sandy or coral coastal soils, or even brackish water. The plant only has a single terminal bud, making attacks by pests and diseases extremely dangerous. Coconut has a very low propagation capacity: 50 to 150 seednuts per palm per year, which limits the distribution of improved planting material. The fruit contains coconut meat that is rich in lauric oil, the only oil of this type along with palm kernel oil.

The coconut palm originates from the Asia-Pacific region and was domesticated very early by man, so much so that wild types are no longer found. This palm, by providing local populations with food, drink and various materials, has become an integral part of civilization in producing countries, e.g. by marking land ownership. Production occurs in quite contrasting situations: island and coastal zones, characterized by isolation, with small populations and poor inhabitants, and lastly the rareness and low value of arable lands, or in zones with substantial coconut development where better land and labour are abundant.

Coconut is mostly grown by smallholders in small plots: 95% of coconut plantings cover an area of under 3 ha. Many farms do not belong to the producers, who ensure their upkeep, but are cultivated under share-cropping contracts. It is a crop of poor rural populations and may be the only source of income in many "marginal" situations (sandy coasts, atolls, remote valleys). Under such conditions, cultivation is not intensified and yields are low, rarely exceeding 800 kg/ha on smallholdings.

Coconut was initially a food crop, but became more speculative with the development last century of the copra sector, which was then geared towards meeting the oil needs of advanced nations. Nowadays, coconut is primarily exploited as an oilseed. Copra (dehydrated coconut meat) is prepared by producers using rudimentary techniques. The product is then taken to oil mills via a complex and speculative marketing circuit. A small proportion of the harvest is processed into desiccated coconut, or coconut milk and cream, which provides greater added value. Although still low, demand for these products is increasing steadily, notably in Asia.

The crop occupies 11 million hectares, producing 7 to 8 million tonnes of copra equivalent, i.e. a turnover of 16 to 17 billion francs. A third of production is consumed domestically in the production zones, in fresh form, the remainder being marketed as copra, i.e. just over 5 million tonnes.

Half of the 3 million tonnes of oil obtained is consumed in the producing countries, the rest going onto the world market. Copra oil belongs to the laurics group and has specific outlets (soaps, detergents, oleochemistry and cosmetics), which give it a comparative advantage over rival oilseeds (premium). However, the poor quality of marketed copra penalizes the commodity channel in terms of both processing costs and marketing.

Over and above unfavourable socio-economic contexts, production is subjected to a whole series of constraints that limit the yields, productivity and profitability of coconut cultivation. These include slow growth and start to bearing, making coconut cultivation a long-term investment, numerous, often deadly, regional endemics about which little is known and which involve numerous pathogens, or considerable fluctuations in yields, subjected to climatic adversity, natural accidents and the biological cycle of the plant. Not only do these substantial fluctuations penalize producers, they also have negative repercussions on demand from the international market, and lastly on prices.

Challenges and issues for research

The coconut commodity channel is geared almost exclusively towards copra and oil production and has difficulty competing with other tropical or even temperate oil crops. The gradual sinking of world prices has slowly reduced the profitability of coconut and farmers' interest in this crop. If the copra sector were to disappear, it would cause macro-economic problems: supplies of copra oil to the markets, including the domestic markets in the producing countries, along with the removal of a major exportable resource for some countries. It would also be catastrophic for millions of smallholders for whom copra is the main source of income. The major challenges for the coconut commodity channel can thus be described as follows:

Maintaining the copra sector by increasing its competitiveness and strengthening the profitability of coconut cultivation for growers, which means:

- increasing agricultural productivity in both monocultures and intercropping systems,
- improving the quality of copra and its derivatives,
- diversifying product use (oil and presscake) through secondary processing (new food or oleochemistry products).

Preventing the risk of coconut plantation disappearance through lethal decay diseases:

- study of risks and identification of the causal agents,
- utilization of genetic resistance (tolerance),
- rapid dissemination of planting material selected for that purpose.

Improving the income of producers who depend on coconut cultivation (island sites) by:

- increasing agricultural productivity in smallholdings,
- production diversification (intercrops)
- development of smallholder processing activities (that can be adopted by producers) or industrial processing activities, which ensure better commercial development of production.

Reconversion of part of the coconut commodity channel to types of use other than copra:

- development of processing technologies,

- adaptation of planting material to new requirements,

- adaptation of primary production to fresh processing (intensification, collection basins, production under contract, quality considerations).

It should be noted that since a large share of production comes from smallholdings, all work intended to improve coconut plantation management, harvest utilization and farmer incomes, will depend upon a precise diagnosis of the production situations and identification of demand from stakeholders.

Current situation: programme skills and strategy

A lack of public and private research is a further characteristic of the coconut commodity channel, which lacks the capacity for analysis and reaction to cope with the challenges facing it. Thus, the strengthening of existing research arrangements is an objective of paramount importance for producing countries, hence for CIRAD. CIRAD is the only organization in the North working on this plant in any significant way, though coconut is considered as a priority by international funding agencies (FAO, CGIAR). The coconut programme will endeavour to support the increase in local team skills through training, scientific exchanges (agrophysiology with the Philippines, *in vitro* culture with the Philippines and Mexico) and through collaboration in bilateral agreements, regional cooperation, networks, be they specialized (COGENT) or not (e.g. BUROTROP).

The coconut programme possesses skills in its own right, albeit in limited numbers, that can be effectively brought into play to deal with research issues, or propose adequate solutions to Development: agronomy, physiology-modelling, breeding-genetic resources, biotechnologies, crop protection. It can also receive back-up for skills recently transferred to other programmes, but which can still be mobilized: crop protection, and chemistry-technology in particular. In addition, the coconut programme can call for methodological support from the other CIRAD departments, in most disciplines, each time it proposes a subject likely to be of interest to them. Lastly, it benefits from wide experience in most of the coconut zones, and acknowledged expertise capacity, which should facilitate partner identification.

However, the coconut programme does not possess skills in a certain number of fields, primarily in social sciences (especially economics), but also technology for which it now barely possesses more than an appraisal capacity. These gaps are a veritable handicap for more effectively taking into account the smallholder dimension of the commodity channel and for increased involvement in the production processing-commercial development sector.

Recruitment of a specialist in each of the disciplines seems essential if the programme is to be fully involved in the smallholder farming field.

Failing that, new skills will have to be brought in from specialized CIRAD programmes: “Humid Tropics”, “Smallholder Farming”, “Agrifood Systems”, or even “Economics, Policies and Markets”, which have researchers with the right economic expertise for coconut. It should be noted that in some cases, collaboration already exists and the presence of former colleagues in the given departments should make it easier to set up joint projects. It is also worth noting along those lines the numerous possibilities of collaboration with ORSTOM (with whom we already work on joint operations) and with scientific institutions in the North (Universities, INRA, Long Ashton). Lastly, the coconut programme often works in close collaboration with the oil palm programme, enabling the two programmes to pool available resources.

In the South, the programme can rely on the support of numerous partnerships enabling it to work in the field. The programme’s researchers have access to three stations (Ivory Coast, Vanuatu and PNG), in two major production zones for CIRAD (Africa, Pacific).

In the major producing countries, our possibilities are more limited but do exist: technical assistance contracts signed with large groups in Indonesia, collaboration with PCA and PCCARD in the Philippines. Worth mentioning too in relation to these same countries is our much appreciated involvement in smallholder development in Indonesia and the Philippines (World Bank Project).

New partnerships will have to be sought based on projects we shall be setting up in the next 5 years. This brings to mind Mexico (collaboration with CICY and INIFAP on lethal yellowing), Ghana (Cape Saint Paul disease, coconut smallholding development), and Benin (drought control, smallholder processing), etc.

Research projects

Research activities will be concentrated in three multidisciplinary projects:

①- **Improving the competitiveness of the copra sector and producer income.**

Study of coconut-based farming systems (monocultures or intercrops), typology and production system diagnosis. Understanding the functioning of the plant (and of the intercrops in the same plot) and drawing up representation models (collaboration with the "Agronomy" scientific support programme).

Optimization of soil conditions (irrigation and fertilization). Research into the adaptation of coconut to marginal conditions (collaboration with Agronomy and the INRA Underdrought programme). Breeding of planting material adapted to operating conditions (ecology, degree of intensification, parasite pressure, harvest utilization).

For many aspects, these research topics could be covered in collaboration with the oil palm programme (plant architecture modelling, carbon assimilation and use of assimilates).

②- **Integrated control of coconut lethal yellowing: case of the Mexico-Caribbean zone.**

Etiological studies of the target diseases (lethal yellowing and *Phytophthora* rot) and identification of causal agents (genetic variability of causal agents). Development of tests to assess disease susceptibility/tolerance. Assessment of genetic resources with a view to searching for genetic resistance (combining of molecular marker and conventional screening techniques). Breeding/creation of improved planting material (resistant and high-yielding in the field). Rapid propagation of the material for distribution to growers (combinination of conventional seed production techniques and vegetative propagation/*in* vitro culture).

This highly unifying theme combines both a conventional disciplinary approach and the most modern approaches developed for crop protection, genetics and biotechnologies. This project, which will be implemented first of all in the Mexico-Caribbean region (request from the Mexicans, existence of teams and laboratories with adequate potential, ORSTOM's interest in that country), could have numerous repercussions in other regions faced with identical problems (West and East Africa, Asia). For the coconut programme, it would therefore be a model for the type of response we can provide to the problems encountered in producing countries: bringing into play modern scientific resources to solve a development question.

③- Back-up for the diversification of coconut uses

Definition of crop management sequences appropriate for smallholder situations that respond well to the identified challenges: adapted planting material, integration of the crop into existing farming systems, strengthening of its sustainability (soil fertility conservation or restoration, study of coconut-based farming systems with annual and perennial intercrops, promotion of livestock rearing under coconut, agroforestry with bushy legumes, crop stabilization in devolution zones). Transfer of small-scale technologies for the commercial development of coconut products and by-products (fuel oil sector, small experimental desiccated coconut and edible oil production units, coconut wood). Accompanying the coconut commodity channel in its development towards new types of commercial development: technology transfer, back-up for upstream aspects (supplies to units, rehabilitation and organization of the catchment area) and downstream aspects (market research for new products).

This work should bring into play specialists from the coconut programme (general agronomists, development specialists, technologist for back-up), and from the Agrifood Systems, Humid Tropics and the Economics, Policies and Markets programmes.

The Coconut Programme

CHALLENGES	ISSUES FOR RESEARCH	PROJECTS
▸ Improving coconut cultivation profitability under smallholder conditions ▸ Restoring the competitiveness of the copra sector, the main source of oilseeds in producing countries and the main lauric source for oleochemistry worldwide	- Increasing, securing and diversifying production in coconut-based farming systems: . adapted and high-yielding planting material . coconut palm functioning in monocultures and intercropping systems . adapted crop management sequences (fertilization, integrated control of diseases, etc.) . production diversification	**1- Improving the competitiveness of the copra sector and producer income**
▸Maintaining coconut in countries where it is grown traditionally, for the important role it plays in economics, food supplies and culture	- Strategy for preventing the risk of coconut disappearing from production zones that can be affected by a type of lethal decay	**2- Integrated control of coconut lethal yellowing: case of the Mexico-Caribbean zone**
▸ Developing alternatives to the copra sector in the smallholder environment ▸ Settling populations affected by the decline in the copra economy (insular type peripheral zones).	- Developing smallholder processing technologies - Adapting primary production to new activities (crop intensification, producer organization, production under contract) - Economic assessment of innovations upstream (primary production) and downstream (market for new products)	**3- Back-up for diversification of coconut uses**

The Rubber Programme

Characteristics of the commodity channel

Hevea cultivation has a natural range throughout the humid tropics. Its status as "artificial" forest could lead it to become a major element of environmental protection in some countries.

Asia alone produces 92% of the 6.3 million tonnes of natural rubber (i.e. a turnover of 40 billion francs in 1995) used annually worldwide, 7% comes from Africa, and the rest (1%) from Latin America, where it has never been possible to develop *Hevea* because of a pathogen, *Microcyclus ulei* which, although still confined to that continent, is a latent threat to the rest of the world.

Hevea plantings amount to 8.5 million hectares, 80% of which are smallholdings with average yields of 500 kg/ha. The remaining 20% are estate plantations producing 1,500 kg/ha.

The number people involved in this agricultural activity is estimated at 50 million. French and European development companies are involved in this activity in Asia, Africa and South America.

Despite the development of a wide range of synthetic rivals (9 million tonnes/year) and variability in its quality that has still not been mastered, natural rubber has remained a strategic material because of its unrivalled physico-chemical properties that make it technically largely preferable in the tyre industry (70% of its uses), in which Michelin is the world leader, the latex industry (8%), technical rubbers (cables and seals, 7%) and shoes (5%). Its consumption is therefore continuing to increase, especially in the developing countries of Asia and Latin America, to which the processing industry has also moved over the last few years.

However, its production is handicapped by:

- a *Hevea* clonal propagation method by budding that does not enable optimum use of selected root system potentials,

- long returns on investment, due to the relatively slow growth phase of *Hevea* (it still takes 5 to 6 years, under usual conditions, to obtain a tappable tree),

- considerable labour requirements, due to an exploitation cycle comprising repetitive tappings that cannot currently be mechanized,

- production incidents caused by the tapping panel dryness syndrome which, as a first approximation, seems to affect 8% of trees tapped worldwide,

- the transfer of technical innovations to smallholders, which has yet to be properly mastered.

Moreover, its economic life span, which used to be at least 30 years, is now tending to decrease in Southeast Asia, due to an increasing interest in rubber wood, which has become a very widely used material in that region, but has remained largely unexploited elsewhere.

Challenges and issues for research

Given these constraints, *Hevea* is faced with severe competition from other crops, urbanization and industrialization as regards production factor availability in the most suitable production zones, especially in Malaysia and Thailand, which account for almost 50% of world natural rubber production. Faced with increasing demand and uncertain production trends, there is therefore a risk of shortages early in the next century, which is already inciting some major tyre manufacturers to brandish the threat of changes in their consumption habits if the commodity channel is unable to guarantee both supplies and prices. This demand is leading the commodity channel to produce more and better, whilst more effectively controlling its production costs.

Producing more means promoting *Hevea* development in countries where natural rubber still remains a first class socio-economic development asset, whether that be in:

- countries with strong population growth, such as Indonesia, Vietnam and the African countries,

- or in countries with a high present or future consumption potential but where physical environment aspects are marginal, such as the Central Highlands of Vietnam, northeastern Thailand, or *Microcyclus* "escape" zones in Latin America.

Producing better means improving productivity and primarily tapping output, which is a prerequisite for the long-term survival of *Hevea* cultivation.

In order to produce more and better, the natural rubber commodity channel is now consequently in search of a new *Hevea* cultivation system enabling the integration of *Hevea* into viable farming systems from a social, economic and ecological point of view, hence:

- cropping systems, in traditional or non-traditional zones, that optimize the integration of *Hevea* into the smallholder environment, and the complementarities of *Hevea* tapping and wood exploitation cycles,

-ways of preventing and controlling diseases, and *Microcyclus ulei* in particular,

- fast-growing planting material with potentially high, quality rubber yields and/or wood yields in different smallholder and parasite pressure contexts,

- *Hevea* exploitation methods that optimize the expression of production potential in terms of both productivity and the laboriousness of tapping work,

Current situation: assets and skills

In order to meet the demand from the commodity channel, the Rubber Programme has assets and skills that enable it to operate in the different fields involved.

Thus, from a cropping systems point of view, the studies conducted since 1993 on competition in farming systems combining *Hevea* with intercrops in Indonesia, Gabon and the Ivory Coast, on the adaptation of *Hevea* to conditions in the Highlands of Vietnam and on improvement of the

Hevea-based agroforestry system in Indonesia, already enable it to propose new crop management sequences for new sub-optimum zones.

As regards leaf diseases, significant progress has been made on *Microcyclus ulei,* for which more is known about pathogen diversity and against which a strategy has been defined for developing the general resistance of clones. Indeed, CIRAD is currently the only organization in the world truly working on this problem.

As regards planting material breeding, CIRAD is also probably alone in developing a set of tools and collections with the RRIM (Rubber Research Institute of Malaysia) that enables:

- the exploitation of *Hevea* germplasm,

- characterization of its genome,

- the implementation of rational creation, early selection and large-scale clone study schemes,

- marker-assisted selection.

In the field, it has access in particular to two planting material creation bases, one in the Ivory Coast, a traditional cultivation zone, the other in Brazil, which is a non-traditional zone. Lastly, it has access to a network of trials including three Asian countries, three African countries and three American countries.

Hevea tapping is CIRAD's field of excellence. Indeed CIRAD was able very early on to link the physiology of flow and latex regeneration between two successive tappings. Latex diagnosis, which is a long-term production forecasting and management tool involving a study of four physiological parameters, is currently the most significant outcome of research carried out on this subject, based on:

- developing and continually updating an agrophysiological model of production,

- continually feeding information from this model into a molecular and cellular marker identification activity, with a view to fine-tuning diagnosis tools, acquiring an understanding of tapping panel dryness and, lastly, guiding genetic improvement towards the creation of material adapted to a reduced tapping frequency.

In the field of rubber quality, CIRAD is in an interesting position, at the interface between plantations and processors in the North. It also has first-hand knowledge of how clonal origin, along with tapping, collection and drying methods affect rubber properties. Furthermore, a way of measuring molecular sizes directly linked to the processing properties of rubber has been defined.

Lastly, in the biotechnologies field, CIRAD is some way ahead, with several hundred plants obtained by somatic embryogenesis in the Ivory Coast, Nigeria and Thailand for agronomy trials.

The programme's strategy and research topics

Based on the above concerns, the assets of the programme and its operational capacities, the department will be concentrating on the following four major fields:

- mastering transfers to smallholders, especially in sub-optimum production zones,
- controlling *Microcyclus*,
- controlling productivity per area, work output and investment,
- somatic embryogenesis and processing.

In order to do that, and in compliance with the external review, the Rubber Programme proposes to give top priority to:

- reintegrating its studies of latex system functioning into a more overall approach of whole plant functioning, which is essential for understanding *Hevea* growth and production in sub-optimum cultivation zones,
- in conjunction with processors, re-aligning its concept of rubber quality that should be modelled within an approach extended to ecophysiology and breeding.

It also proposes to strengthen its research potential in molecular physiology and genetic engineering, which are particularly apt to come up with the most effective products and solutions for use in solving flow, yield and quality problems.

Such strengthening will have to come from CIRAD scientific support programmes, but also from ORSTOM, which remains an essential partner in the field of molecular biology, and also from research organizations which, in the North, are ready to provide scientific assistance in return for access to the field.

The programme will also step up its current most efficient cooperation activities with:

- IDEFOR and HEVEGO in the Ivory Coast, which given past history and the network developed by IRCA up to 1991, are inevitable partners in the field,
- MICHELIN, our most efficient partner in Latin America, for setting up a variety creation pole, which is probably unique in sub-optimum production zones,
- RRIT and Kasetsart university in Thailand, where the rubber programme could have access in the medium term to a strong research base in the field of genome mapping, and whole plant modification and physiology.

Lastly, and if possible in a regional approach, the department will promote cooperation likely to provide access to the major rubber development operations emerging in Asia (Vietnam, Cambodia, Thailand), in Africa (Ivory Coast, Cameroon) and in Latin America (Guatemala, Mexico), which alone will enable it to conduct participatory research with smallholders, in conjunction with the TERA department's "Humid Tropics" and "Smallholder Farming" programmes.

Research projects

All in all, most of the research operations will be grouped under four projects, the first corresponding to joint fields of study (in Vietnam and Indonesia) identified with the HT and SF programmes of the TERA department, the other three calling for some of their operations to be conducted with AMIS programmes. The projects are as follows:

①- Analysis, diagnosis and designing of cropping systems adapted to smallholdings

Over 4/5 of the areas planted with *Hevea* are family smallholdings. In the global context of economic liberalization and the privatization of State-owned companies, that fraction is growing rapidly. The very low productivity levels on these production units (0.4 t of rubber/ha/year) is far from the true potentials developed on research stations and observed in estate plantations (1.6 t/ha/year). Less effective use is made of smallholder production. Moreover, the expected production shortfalls are leading to an extension of its range into non-traditional zones, where *Hevea,* through its hardiness, can help to improve yields from farms in marginal climatic zones when intercropped with other annual or perennial crops.

②- Study of *Hevea / Microcyclus ulei* interactions for the creation of resistant material

This project participates in securing supplies to the natural rubber market. In fact, it aims to establish the necessary knowledge base and an adapted *Hevea* germplasm, to enable a rapid reaction by the commodity channel in the event of accidental introduction of *Microcyclus* in the major cultivation zones, and to consolidate and extend South American rubber growing which is currently developed in so-called escape zones.

To a certain degree, this project participates in developing *Hevea* cultivation in the so-called new or "sub-optimum" 'escape' zones (project 1) characterized by a marked dry and cold season.

Given the essential characteristic of the *Hevea / Microcyclus* pair, which most probably proceeds from the "gene for gene" model, and of specific resistances, research is attempting to enhance knowledge about the fungus and its interaction with *Hevea*, in order to confirm this hypothesis. It is also seeking to discover the underlying existence of general resistance mechanisms. The aim is to identify and genetically combine independent and complementary components of general resistance, which seems substantial within wild Amazon *Hevea* germplasm.

③- Improvement of tapping productivity: adaptation of planting material to tapping techniques

This project is intended to improve the competitiveness of *Hevea* cultivation, by improving plot productivity and output for non-mechanizable tapping work.

Natural rubber is a very original agricultural product insofar as it results from the artificial diversion of part of the primary metabolism to the benefit of secondary synthesis of latex maintained by tapping. The degree of such deviation has limits defined by the inherent production potential of each clone. Production is the result of an interaction between the clone, its tapping intensity, and environmental conditions.

Improving tapping productivity is based on the CIRAD metabolic typology concept of laticifer system functioning, which determines the possibilities of adaptation to reduced tapping frequencies compensated for by hormone stimulation, both in terms of genetic improvement and of tapping panel management systems. These systems affect the process of metabolic partitioning between biomass production and latex production, hence overall tree functioning.

④- Development of somatic embryogenesis and genetic modification methods

The future of *Hevea* cultivation is linked to a substantial increase in plantation productivity, be it in traditional cultivation zones or in new zones. Biotechnologies offer the quickest way of improving planting material quality through:

- cloning by somatic embryogenesis, which should improve the vigour and homogeneity of selected genotypes,

- selection of genotypes on their own root system, thereby enabling more effective exploitation of genetic variability,

- genetic modification and regeneration of modified cells by somatic embryogenesis; this line of research would enhance knowledge of rubber production mechanisms, but it would also eventually make it possible to modify certain characters linked to such production, to the characteristics of the rubber and to resistance to certain diseases.

The somatic embryogenesis process, defined in previous years, needs to be extended to different clones of interest and perfected, before development of the technique can be envisaged. A method of stable genetic modification needs to be developed and the somatic embryogenesis process needs to be adapted to obtain reliable regeneration of modified plants.

⑤- Controlling and reducing variability in rubber quality

Natural rubber users, primarily tyre manufacturers, are obliged to seek ever increasing automation for the manufacture of increasingly technical products at increasingly competitive prices. Such manufacturing processes require perfectly defined and consistent raw materials. Unfortunately, manufacturers find excessive variability in natural rubber, which results in the manufacture of faulty articles that have to be rejected, and to higher production costs.

Furthermore, quality criteria that are measurable at the production site cannot be used to predict the performance of rubber during processing.

The development of private contract markets has introduced closer customer-supplier relations and the appearance of specification ranges requiring perfect knowledge of how clones, soil, tapping and processing methods affect product quality.

Rubber Programme

CHALLENGES	ISSUES FOR RESEARCH	PROJECTS
▸ Extending the areas planted with *Hevea*.	- Adapting *Hevea* to zones where it is not traditionally grown. - Adapting *Hevea* cultivation to smallholdings. - Controlling *Microcyclus* in Latin America.	**1- Analysis, diagnosis and design of cropping systems adapted to smallholdings.** **2- Study of *Hevea/Microcyclus ulei* interactions for the creation of resistant material.**
▸ Increasing the productivity of cultivated plots.	- Reducing the immature period. - Increasing tapping output.	**3- Improvement of tapping output: adaptation of planting material to tapping techniques.** **4- Development of somatic embryogenesis and genetic modification methods.**
▸ Controlling natural rubber variability	- Developing tests to predict natural rubber performance during manufacture. - Identifying influential factors. - Proposing treatments to regularize quality.	**5- Control and reduction of variability in natural rubber quality.**

Oil Palm Programme

Commodity channel characteristics

Development of the oil palm commodity channel remains strong. Palm oil, which is the number one vegetable oil export, will be top of the world production league, overtaking soybean, in the years to come (over 17 million tonnes in 1997, i.e. a turnover of around 50 billion francs).

This growth is primarily due to Malaysia, which is pursuing its extensions to the detriment of rubber and cocoa plantations, whilst continuing to replant (second generation), and to Indonesia, which is expanding at a rate of 200 to 300,000 ha per year. Some other countries are also very active, albeit more modestly (PNG, Thailand, Colombia, Ecuador), whilst newcomers have planting programmes that will have to be considered in the future (India, Brazil, Mexico, etc). Africa, whose State-owned plantations are undergoing privatization (Ghana, Ivory Coast, Cameroon, etc) is following more slowly for structural and sometimes economic reasons.

Such development results from true comparative advantages:

▸ oil yields per hectare well above those of any other annual or perennial oil crop, enabling effective intensification where agricultural land is in great demand,

▸ versatility of the oils produced, for both food (refined table oil, margarine, etc.) and non-food uses (soaps, cosmetics, fatty acids, etc.),

▸ buoyant palm oil and kernel oil prices in recent years, due to a chronic oils and fats deficit: expanding populations and growing per capita demand (China, India, Pakistan, Vietnam, etc.),

▸ substantial profit margins with quite rapid returns on investment (production from 3 years compared to 5 years for *Hevea*),

▸ available land for development in some countries (Indonesia),

▸ available manpower, except in Malaysia.

Most of the production (over 80%) comes from large agro-industrial complexes covering thousands of hectares and possessing palm oil extraction units with appropriate capacities, belonging to large groups (Malaysia, Indonesia).

Due to land tenure problems linked to local population pressure, it is becoming increasingly difficult in some countries to obtain large concessions, which has resulted in the development of family farms and smallholdings, either in industrial type structured blocks (FELDA in Malaysia, *Plasma* in Indonesia) or scattered individual farms (Ivory Coast, Cameroon, Colombia) of a few hectares to several dozen or several hundred hectares. In countries where the commodity channel is developing strongly, the main challenge is access to land that is still available.

The competitiveness of the commodity channel needs to be assessed on several levels:

- on an international level in terms of cost prices compared to other oils on the market (soybean, sunflower, rapeseed, etc.), given that they are all partially chemically interchangeable (hydrogenation process, etc.),

- on a regional or national scale, based on comparative advantages compared to other producing countries (environmental conditions, farming systems, monetary policy, taxation, etc.).

On a global scale, the conditions in Southeast Asia provide the best profit margins, though they are tending to decrease on average due to extensions planted in more restrictive zones (soil, climate, access), and to the scarcity of manpower and/or increase in labour costs.

In Africa, the dynamic revival of the commodity channel (first generation replanting, smallholder extensions) depends on the possibility of mobilizing investments and on the performance level that smallholdings adopting oil palm will be able to achieve. There are also immense reserves to be developed once socio-economic constraints have been lifted (Congo Kinshasa, Congo, Liberia, etc.).

In Latin America, the commodity channel is showing proof of true dynamism despite socio-political situations that are sometimes difficult (Colombia) and the relatively generalized existence of oil palm lethal decay diseases.

Challenges and issues for research

In Asia, given the widespread structuring into large agro-industrial type estates, research progress is incorporated quite easily and rapidly into the crop management sequences. This commodity channel, which is resolutely geared towards exports is therefore seeking every possible way of intensification: progress in potentially high-yielding planting materials, appropriate crop management sequences, worker output, efficacy of the industrial extraction tool, increase in the added value of products and by-products. Correlatively, problems linked to environmental degradation (massive deforestation, slash and burn extensions and fires, pollution of the atmosphere, rivers and water tables) will have to be taken very seriously into account for development to be standardized and acceptable to the international community.

Planting substantial areas each year presupposes access to top quality commercially available planting material: shortages have been seen, with second rate seeds or even potentially catastrophic non-selected seeds coming onto the market. The detriment to a grower, whoever he is, when he plants palms of doubtful origin for a period of twenty years, is easy to imagine. Providing growers with high-yielding materials remains one of the priority objectives of research.

Acquiring a clearer understanding of plant functioning in its environment means gradually developing models, from the simplest to the most sophisticated, in order to calculate production potential at a given site, and forecast annual yields and their distribution throughout the year, adapting planting densities to the planting material/soil/climate trio, providing fertilization at the right time, in line with true requirements, etc.

Planting oil palm under the best soil and climatic conditions means favouring higher yields per hectare at a lower cost, but also benefitting from good yield distribution throughout the year. Under less favourable stress conditions, with a water deficit for example, yields are more limited, with most of the production concentrated in 3 or 4 months only, which is highly detrimental for both operating conditions and costs. Attempting to spread out production will be one, undoubtedly ambitious, objective.

Dealing with the sustainability of the crop means taking a multidisciplinary approach to aspects raised by replanting: evolution of soils and their fertility, solutions to increased pressure from diseases, pests and weeds. During the first generation, Bud Rot in Latin America, for which the etiology remains unknown, is responsible for the disappearance of entire plantations: what can be proposed for the next generation? Vascular wilt in Africa, *Ganoderma* (fungal diseases) in Asia, Marchitez (trypanosomes), Red Ring (nematodes) in Latin America, and pests (*Oryctes*, *Rhynchophorus*, a large number of leaf-eating caterpillars) are still serious threats, either locally or regionally, to the commodity channel, though integrated control methods are making steady progress.

Faced with the keen interest of smallholdings and family farms in oil palm, which is rarely the only crop on the farm, a risk of lower oil palm productivity can be feared. Supporting and training these farmers in the overall management of their farms means taking into account not only their crop management sequences, but also their work organization, their representation in professional agricultural organizations and commercial outlets for their produce (FFB or oil already extracted).

The future of the commodity channel depends not only how crop management sequences or possible obstacles are handled; assessing and anticipating socio-economic developments, measuring the impact of sometimes substantial variations in foreign exchange rates, comparing input and labour costs to the prices fetched by products on national or international markets, can all be of help to development operators: national agricultural policies, private companies, professional organizations.

Oil mills, irrespective of their capacity, need to watch over the quality of their products and move towards greater efficiency and less pollution under the dual pressure of economic cost-effectiveness and environmental conservation.

Diversifying the commercial products that could be made from palm oil, palm kernel oil, vegetative parts (fronds, stem, sap), pollen and oil mill by-products (empty bunches, shells, fibres, effluents) is an important objective, especially if it means a good added value: which is bound to set the commodity channel on an even sounder footing.

Current situation: assets and skills

In terms of oil palm genetic improvement, CIRAD plays a strategic role in the methodology applied and in obtaining new varieties with its partners in Africa (IDEFOR, INRAB, IRAD), Indonesia (IOPRI, SOCFINDO) and Brazil (EMBRAPA), right up to variety dissemination: over 60% of the selected seeds on the market result from these breeding programmes.

Planting material with high vascular wilt tolerance is available to growers in Africa, whereas the selection of material with Bud Rot tolerance for Latin America is under way.

In vitro culture is encountering a somaclonal variant problem, which must absolutely be solved if planting material obtained by this technique is to be usable by growers. Strengthening the CIRAD/ORSTOM molecular biology team should remove this bottleneck in the coming years. Moreover, such vegetative propagation will be unavoidable once genetic modification is touched upon.

In ecophysiology, the Oil Palm Programme has limited human resources (just one researcher) and he will have to make optimum use of the knowledge cumulated about oil palm-based farming system functioning, by forging links with other CIRAD methodology programmes ("Agronomy", "Plant Architecture Modelling").

In terms of agronomy, practical control of mineral nutrition and its consequences for the rational fertilization of plantations now needs to be enriched by a study on how such nutrition functions, which is a very important factor for crop intensification.

For crop protection, IPM has made considerable advances over recent years with pheromone trapping, the use of entomoviruses, etc. (collaboration with INRA). However, the causal agent of Bud Rot (Latin America) has still not been discovered, which severely slows down the selection of material with tolerance of this disease, for which inoculation remains impracticable.

A better understanding of rudimentary oil extraction installations enables us to advise users and improve the efficiency of their equipment in a highly significant way. The Drupalm® process of whole fruit crushing now needs to be used on a true scale.

The Oil Palm Programme Strategy

The programme's strategy is founded on four basic considerations:

- The oil palm is traditionally a valuable source of oil throughout the humid tropical belt of Africa. Given the privatization of State-owned companies that is currently under way, the smallholder sector is no longer really supervised and its development is suffering: problem of access to inputs, seasonal credit, planting material, etc. Provided replantings and extensions can be carried out, it is through smallholdings that Africa will extricate itself from the oils and fats shortage situation in which it currently finds itself. Focusing our research activities (crop management sequences, socio-economic problems) on smallholdings is therefore a priority.

- Searching for crop intensification factors in Southeast Asia, which is currently affected by the economic crisis, is a major challenge for those countries: planting material potential, work output, adaptation to soil and climatic constraints, better commercial development of products, etc.

- In Latin America, the main obstacle to development of the commodity channel is the Bud Rot risk. Determining the causal agent and speeding up tolerant high-yielding material production are a challenge that has to be taken up.

- Being so close to the *in-vitro* goal and not being able to use this technique, which could lead to a 15 to 25% leap in oil production per hectare, is not acceptable: stepping up research with modern molecular biology tools is essential.

The programme and department will therefore have to:

- *Position itself at the cutting edge of scientific progress in all the sectors in which it is already acknowledged, though without seeking to cover all aspects of the commodity channel.*

- *Take the risk of embarking on research whose applications could be paramount for the commodity channel, even if they only occur in the long term.*

- *Be widely present in the field (full-time assignments and missions) supporting research, development and training for our public and private partners involved in the commodity channel.*

Research projects

1998 - 2002 programming breaks down into two regional projects (Africa, Latin America), given the specificities identified for each of these continents, and two projects of global interest.

①- Support to smallholdings incorporating oil palm in Africa

Oil palm development on smallholdings is becoming increasingly important throughout the traditional cultivation zone with optimum or sub-optimum conditions. The switch from shifting cultivation on cleared forest to sedentarization through replanting and reconversion from food crops and shrubby crops to oil palm, and intercropping or mixed cropping with other crops, are inevitable. Links with the agro-industrial oil palm sector, which favoured rapid developments in crop management sequences, have become somewhat overstretched since the privatization of State-owned companies in terms of supervision, seasonal credit and primary processing. Structuring of the smallholder sector in major oil palm development zones is one of the priorities for enabling its consolidation and increasing its efficiency.

②- Factors for sustainable intensification

Through its close relations with many private companies in the oil palm commodity channel, CIRAD has first-hand experience of the constraints encountered in oil palm monocultures by growers in agro-industrial complexes.

High production and productivity require constant vigilance as regards soil fertility, pests and diseases, and harvesting techniques, and, at the same time, greater knowledge of the ecophysiological elements involved in yield elaboration is necessary for proposing new planting materials as soon as possible that perform increasingly better and are adapted to environmental conditions.

③- Integrated control of Bud Rot in Latin America

Oil palm Bud Rot (BR) is the most important factor limiting oil palm cultivation in most Latin American countries. Despite a great deal of research conducted without success to identify the causal agent and possible role of vector insects, the selection of tolerant and high-yielding materials will eventually be the practical response to requests from growers.

Without being simple or quick, the genetic approach provides all the guarantees of success, provided both human and material resources are assigned to it. The search for the causal agent is more problematic due to the absence of probable hypotheses based on clearly established situations. A range of proofs confirms that BR is due to an infectious factor whose propagation, whilst being primarily in the air, does not rule out soil involvement. Fungal and nematode hypotheses would be worth examining, but the role of insects as vectors of viruses (or of virus-like organisms) or bacteria will also have to be more closely examined.

④- Mastering oil palm somatic embryogenesis

Several laboratories are working intensively on the obstacle raised by the mantled abnormality. The ORSTOM/CIRAD team should be able to make a significant contribution towards mastering clone conformity, whose economic stakes for the commodity channel are obvious.

The technique of multiplication by embryogenic suspensions is also proposed by the same team: it should enable large-scale propagation more cheaply than the conventional technique developed in 1980, provided it is studied and tested in order to ascertain all its constraints too.

Oil Palm Programme

CHALLENGES	ISSUES FOR RESEARCH	PROJECTS
▸ African oils and fats deficit ▸ Oil palm a priority ▸ Development of oil palm cultivation in the future primarily on smallholdings	- Improving the competitiveness of the smallholder sector: access to planting material, inputs, appropriate extraction, management, professional organizations	**1- Support to smallholdings incorporating oil palm in Africa.**
▸Substantial extensions of estate plantations, notably in Southeast Asia ▸ Often in more restrictive environments	- Commodity channel intensification: . High-yielding, adapted planting material . Adapted crop management sequences (fertilization, integrated control, etc.) . Ease of harvesting . Efficient oil mills - Environmental conservation by limiting pollution (fertilizers, effluents, smoke).	**2- Factors of sustainable intensification**
▸ Major oil palm development potential in Latin America	- Inhibitive risk of Bud Rot (lethal rot) in most of the countries, right from the first generation. - Determining the causal agent - Searching for tolerant planting material	**3- Integrated control of Bud Rot in Latin America**
▸ Vegetative propagation can provide growers with first-class planting material (15-30% higher potential)	- Avoid or circumvent the risks of somaclonal variation - Adapt ramet production to an industrial scale	**4- Mastering somatic embryogenesis**

IMPLEMENTATION

Department organization

In order to develop its scientific project, the department's organization complies with the CIRAD general guidance note (CIRAD organization and operation, principles and methods of implementation).

The departmental flow chart, whose two hierarchical levels are the Management and the Programmes, is given in annex XXX.

The department's Management is responsible for scientific policy, coordination of activities between the programmes, and relations with the other CIRAD departments and services. It is also in charge of programming resources, and their mobilization and distribution between programmes within its budget, along with management of those resources. Lastly, in liaison with general management, it manages and makes optimum use of the skills of the staff assigned to the department (appraisal, assignments, job descriptions, training).

The programmes are where research, development and training actions are designed and implemented. The Head of Programme proposes and implements a budget drawn up in the form of activity projects corresponding to the scientific objectives he proposes to adopt, and which he submits to the Director of the department for budget notification.

The department's Management is backed up by a management support service[4], run by a Head of Service (SAGE), whose skills cover the following fields:

- drawing up the budgets for the department and the programmes,
- monitoring of budget implementation,
- monitoring of contractual resources (cost analysis, drawing up cost estimates, invoicing, recovery),
- links with the joint personnel administration service,
- back-up for local management of expatriate staff or agents assigned to overseas departments and territories,
- monitoring management at installations abroad or in overseas departments and territories placed under the department's responsibility.

Personnel administration proper is the responsibility of central management, with the department remaining the exclusive contact for expatriate staff.

[4] The External Review recommended that administrative and financial management and personnel management be grouped in a single place, in proximity to the researchers in Montpellier. It will not be possible to go through with that recommendation and management will remain divided between Paris and Montpellier, which is a handicap that has to be considered in the department's organization.

A "business development" team has been created to assist the department's management and the programmes to develop marketing policy.

Development and structuring of the research programmes

For a research institution working in a cooperation context, forecasting the lines along which its activities will develop is a tricky exercise. In such a context, the five-year programming plan serves as an "action guide" which, in reference to the main development objectives that have been targeted, enables a choice to be made between different possible interventions. However, in order to effectively cope with socio-economic and scientific changes in the environment, it will no doubt be necessary to revise the programming plan annually.

The programmes have structured their operations in projects and activities.

Projects are defined by a duration, resources and clearly identifiable expected results. They constitute the places where most of the research, but also the development and training operations required to reach the objectives, will be carried out. Each programme develops between three and five multidisciplinary projects that can be split into five major issues (see annex):

- knowledge and improvement of smallholder farming systems: 6 projects,
- improvement of productivity, intensification: 3 projects,
- limiting factors due to diseases and pests: 6 projects,
- quality (genetic and cultural determinants, and intervention in the quality chain): 3 projects,
- somatic embryogenesis and genetic modification: 2 projects.

The activities are primarily sets of continuous or recurrent actions, such as laboratory analyses, management support for an institute or organization other than CIRAD, or carrying out feasibility studies. It may also be recurrent research operations concerning several projects or programmes.

All these 20 projects and activities form a basis for responding to the department's strategic choices. They were drawn up taking into account the department's current possibilities, but also the tools and skills it plans to bring into play, through contracts with other CIRAD departments, but also by setting up cooperation partnerships. Implementation of these projects therefore often involves conditionalities, both inside and outside CIRAD, which may in some cases cast doubt on the very principle of implementing the project in its entirety.

Scientific organization

The supervisory function

In the new structures, a major role has been assigned to scientific delegates for the scientific supervision function, but given the number of researchers in each disciplinary field, it is difficult at this level to take into account "proximity" relations such as those involved in coordination and scientific back-up.

The department divides the scientific supervision function into three parts: information, coordination and scientific back-up.

- Scientific information (state of the art, methodologies, congresses, conferences, etc.) is mainly the responsibility of the scientific delegate, who has a correspondent per discipline in the department,

- Scientific coordination is ensured by the Heads of programmes and project leaders,

- Definition of the type of scientific back-up is under the responsibility of the project leader, in liaison with the researcher, the Head of programme and the correspondent per discipline. The expert in charge of such scientific back-up may come from inside or outside the department, and from outside CIRAD.

The cohesion of this arrangement is under the responsibility of the deputy director in charge of scientific affairs.

Scientific organization also requires that researchers with the same speciality come together regularly on specific tree crop themes. The September "meetings" for CP personnel will be a prime moment for such contacts, which, along with the seminars organized by the scientific delegates, should help in largely attenuating the disappearance of the scientific organization as practised by the research units.

Operational scientific back-up

CIRAD's new structure has enabled the creation of operational scientific support programmes. For instance, a certain number of research actions requiring skills that do not exist or are unavailable at CP can be found in other departments: Department of Advanced Methods for Innovation in Science (AMIS), Department of Territories, Environment and People (TERA), or even in the programmes of commodity channel departments (e.g. the agrosystems programme at CA). Collaboration will therefore have to be established with these different departments based on contracts precisely defining the position of the staff involved and the funding arrangements.

Evolution of scientific skills

An analysis of CIRAD-CP's fields of expertise is given in the annex; it is a collective analysis that provides an idea of variations in current staff over the next five years. The next stage will be to move on to a more individual approach and, depending on the strategic choices of the department (see pages 15-18), organize recruitments and redeployments-training courses, so as to gear scientific skills towards the chosen objectives.

It should be remembered that the fields that need strengthening as a priority are social sciences (for which the department's skills are virtually nonexistent), ecophysiology, disease and pest control (in conjunction with varietal improvement and molecular biology tools), and post-harvest technology.

Among its current members of staff, nine retirements at the age of 65 are scheduled between now and 2002 (but only one between now and 2000). To those need to be added possible departures (between 60 and 65 years old), and gradual cessation of activities. It is therefore reasonable to assume 12 to 13 recruitments over five years.

The figure is not inconsiderable, but the distribution is highly unbalanced and most of the departures (8 out of 9) will be from 2000 onwards. These departures therefore need to be prepared for.

First and foremost, it is urgent to proceed with the recruitment of a significant number of researchers in the department's weakest sector, namely social sciences, and with spot recruitments in the department's fields of excellence, but where strengths are insufficient (ecophysiology, plant pathology, technology).

Redeployments will also be necessary, agronomy being the first concerned since around 75% of the researchers are involved in general agronomy, which should certainly be maintained, though with different numbers of staff and by preparing young researchers for undertaking traditional assessment missions. Another section of researchers, interested in the ecophysiology approach, needs to be steered towards studies on yield elaboration and modelling under the agro-socio-economic conditions most frequently encountered.

Redeployments in the other disciplines (fewer members of staff, or more specialized), or between disciplines, are more difficult to implement and will be considered case by case.

Whatever the case envisaged, it is not very likely that redeployment can take place without a training cycle, which could take various forms: diploma, internal CIRAD course, or a course in another research organization, accompanied appraisal mission, etc.

Training will be organized with the CIRAD's central service; a correspondent will be assigned in the department.

Partnership developments

Within CIRAD

Within CIRAD's current structures, partnership relationships between the programmes of the different departments become decisive. Collaboration with the AMIS department should not raise any problems (conceptual at least) insofar as it involves traditional scientific support. It will not be so easy to establish with the TERA department, since a new way of working will have to be introduced, taking into account socio-economic aspects when defining the relevance of the subjects studied.

So far, by the first quarter of 1998, meetings between the CP programmes and the "Humid Tropics" and "Smallholder Farming" programmes have led to the definition of 6 areas in which joint operations are to be mounted.

In Africa: in Forest Guinea (coffee, oil palm and upland rice commodity channels) and in Sao Tomé (cocoa, food and market garden crops); eventually in Gabon (plantain, cassava, market garden crops, tree crops) in the Ivory Coast (cocoa and oil palm).

In Asia and Oceania: in Vietnam (rubber and diversification crops), in Laos (coffee), in Indonesia (rubber, agroforestry) and in the Pacific, Vanuatu and Papua New Guinea, (cocoa, coconut, food crops); in the longer term in Cambodia (rubber and diversification crops).

Outside partners

The department approves the recommendation of the external review as regards abandoning the idea of its own bases. Indeed, the efforts made in the first years of the previous plan did not open up any concrete avenues.

The proposal to choose target countries is an interesting prospect. It would make it possible to concentrate efforts in places that combine the best conditions for conducting research and development operations. However, targeting a few countries also has its drawbacks. Apart from the risk of political type disruption, which is always difficult to evaluate, choosing between one or several countries and others raises a problem of the bilateral polarization of our operations. Such a move would also be likely to lead us to set up in countries that are already partly equipped, whereas more important needs exist perhaps in the least developed countries.

The department would like to enhance the network concept, which, through the emergence of new communications methods, seems to us to be a possible alternative for limiting the scientific isolation of researchers, though without concentrating them in the same geographical area.

Simultaneously with setting up or consolidating networks, it is important to establish a new partnership in Africa that is truly based on a contractual arrangement, with a view to identifying CIRAD's action and achieving a situation for the commercial application of research results.

As cooperation policies are developing at the moment, priority should be given to seeking such partnerships in at least three fields:

- smallholder organizations and professional structuring (in conjunction with the TERA smallholder farming programme),
- the private sector, with a view to involving large processing and trading companies in production or to act as an interface between private groups and development operators,
- the international research system, with the changing issues of multilateral international cooperation and the rehabilitation of export crops. It is essential for the department to make its skills known within in emerging institutions (NARS group and global forum).

It is most probably in these three fields that the greatest changes can be expected and where the future of agricultural research for the countries of the South will be decided.

The business development policy

The drop in contractual resources has been steady since the department was created, partly because of a downturn in traditional funding sources, and because of the department's own insufficiencies. Following the external review, trends in the traditional and newly emerging markets need to be studied, in order to propose new directions for the department's business development policy. The aim remains an increase in contractual resources, with a ceiling of 28% for 1998, moving away from the extreme concentration on oil palm (52% of the total) and compensating for the reduction in the importance of Africa.

Trends linked to "the market"

The demand for research remains strong, but it has shifted along the two axes specific to the department. On the commodity channel axis, stakeholders are increasingly reticent to get involved in research actions whose economic returns are not clear, and are favouring downstream and upstream areas; on the technical axis, the target countries have acquired a level of skills such that there is no longer a market for basic techniques which they often master very well.

Thus, in order to propose the transfer of innovative technologies, it is necessary to have clear knowledge of their purposes and their practical applications under various physical and socio-economic conditions. The demand for new technologies is strong, provided they are rapidly operational.

▸ *Funding agencies*

The observation for this financial sector is threefold: bilateral cooperation is declining, major projects are less and less based on themes or specific commodity channels, but incorporate very wide development bases, and funding is subject to an association with the productive sector, which guarantees better economic returns on the granted investment.

▸ *Competition*

Competition comes primarily from four areas:

-design offices, which are usually better prepared in terms of the development approach, lobbying know-how, a rapid response capacity, and in terms of cost,

- research centres, many of which have reduced their structural costs and are therefore more competitive than CIRAD; moreover, some of them know how to become unofficially involved as agents of the economic complexes that back them,

- the inter-profession and users, which often have much more extensive R/D resources than those that can be brought into play by CIRAD-CP, be it for operations in the commodity channels (Nestlé, Michelin, Philipp Morris, etc, or across commodity channels, such as biotechnologies.

▸ *New challenges for the CP commodity channels*

These new challenges are changing the nature of the clients. They have been previously analysed and are: globalization and reduced State intervention, commodity channel reorganization, privatization of estate plantations, strengthening of smallholdings, changing the site of primary processing, concentration of trading and processing (coffee, cocoa, rubber), uncertainty about public aid for the commodity channels.

The directions to be taken

▸ *General outline*

Adaptation to today's world means giving thought to the following three aspects: the choice of partners, the products to be proposed, and the modus operandi.

The department has long-standing experience of relations with the private sector in the countries of the North; current trends indicate they are set to develop. There lies behind such collaboration a whole range of funding arrangements that these operators alone can bring into play and from which the department can benefit in return.

However, relations with the private sector of countries in the South and with NGOs are more limited, though it is from these potential partners that the greatest demand for innovative technologies comes. A link-up with these private organizations, associations or NGOs should be sought in conjunction with local research structures.

These operations with the private sector enable validation of research on a true scale and contribute through feed-back towards more effective pinpointing of the challenges, provided that products are available that respond to the needs of stakeholders, with the expected degrees of applicability and outcome, and experts with the appropriate backgrounds are available.

▸ *Lines of force for the CP department*

The business development unit set up in January 1998 comprises two senior staff and organizes its operations in accordance with several basic principles:

1- Giving more consideration to obtaining contractual resources and the commercial development of routine activities

In order to do this, a company spirit needs to be established involving each member of executive staff in obtaining contractual resources with objectives that are assigned and modulated in accordance with activities and their potential. It is also necessary to take into account the true cost of the experts and no longer settle for covering the marginal cost of the operations, the salary being covered by the BCRD.

It is also essential to:

▸ assess the potential commercial development of current research,

▸ professionalize contractualization and strive for sustainable resources,

▸ renegotiate some existing agreements,

▸ protect achievements (planting material, know-how and procedures),

▸ set up a veritable commercial network (as was done for oil palm seeds),

▸ widen the range of products.

2- Acquiring new skills and developing new technologies to maintain expertise potential.

Multiplying appraisal services alone would eventually affect the department's ability to innovate and produce scientific results likely to be of interest to potential partners. Indeed, endeavours must be made to increase the available stock of commercializable results.

3- Strengthening existing partnerships and seeking new ones

Establishing sustainable partnership agreements will be a major axis of the department's strategy, though taking care to dose the degree of exclusivity and confidentiality accorded. Such partnerships will concentrate on:

▸ the major private groups in the North and South, notably for varietal improvement and the control of quality chains,

▸ small and medium-sized businesses, design offices, NGO's n the North and South, particularly for improving access to public and international funds,

▸ small and medium-sized businesses for licence transfers in certain sectors of activities,

▸ the NARS, given the strong collaboration with the department in certain activities such as planting material production and their necessary association when mounting projects with public funding.

4- Product diversification

Even if some new products do not fall directly within the department's field of skills, it is essential to inventory diversification possibilities and, here again, it will be necessary to identify the appropriate partners for any manufacture and commercialization. These could include teaching aids and multimedia information systems.

ANNEXES

1- Achievements of the programmes for the 1993-1997 period

2- Analysis of CIRAD-CP's fields of expertise

3- CIRAD-CP senior scientific staff as of 1st January 1998

4- List of CIRAD-CP projects by major theme

Annex 1

Achievements of the programmes for the 1993-1997 period

Cocoa programme

Three major advances have been made in genetic resources, firstly in the knowledge of genetic diversity and genome mapping (in conjunction with BIOTROP), and in the choice of parents, which has made it possible to create eight hybrids by reciprocal recurrent selection that have productivity traits which are 15 to 20% higher, and increased resistance to *Phytophthora*. Seed gardens have also been set up in Indonesia. These results confer on the cocoa programme a decisive role in the INGENIC network and in the IPGRI-Common Fund project.

Cocoa disease and pest control is a major challenge for productivity and sedentarization of this crop, and noteworthy achievements have been obtained against *Phytophthora* (knowledge of pathogen diversity and assessment of varietal resistance) and against Swollen Shoot (knowledge of the genome of the virus responsible and assessment of resistance by artificial inoculation).

For mirid control, a treatment system using smoke canisters has been invented and is due to be developed in the Ivory Coast.

Farming system analyses are being used for guidance in the rehabilitation of cocoa plantations in the Ivory Coast and Ghana, and for facilitating the distribution in Ecuador of cocoa seeds with characteristics very similar to those of the "Nacional" clone which is prized for its flavour qualities. Knowledge of the plant is also being acquired through modelling of the aerial parts and root system, and by studying its floral biology.

In the flavour field, recent results have identified the links between certain compounds and different stages of post-harvest operations and precursor transformation. That is making it possible to quantify the importance to be accorded to different stages depending on the desired end product and, eventually to strengthen flavour potential. Quality determinism is also being investigated by genetic marker techniques.

Lastly, the development and commercialization of a method to control fermentation and ensure quality consistency in the cocoa produced is currently under way via a private company.

- Recap table for the cocoa programme -

Projects/disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Genetic resources and variety creation	.Knowledge of genetic diversity .Genome mapping .Choice of parents	.Eight hybrids that are productive (+15 to 20%) and more resistant to *Phytophthora* (Ivory Coast)	.Core collection .Cocoa hybrids .Marker-assisted selection .RRS analysis	.Seed gardens in Indonesia
Integrated control of *Phytophthora*	.Knowledge of pathogen diversity .Assessment of genetic resistance		.Resistant varieties	.Chemical control in Cameroon and Sao Tomé
Resistance to Swollen shoot	.Knowledge of virus genome .Diagnosis method	.Assessment of resistance by artificial inoculation	.Resistant varieties	.Selection of hybrids in Togo
Pesticide applications	.Development of smoke canisters and compatible a.i.			.Transfers for mirid control (RPA and the Ruggiéri company)
Productivity of cocoa-based farming systems	.Knowledge of farming systems (Ivory Coast, Ghana, Ecuardor) .Architectural models . Knowledge of floral biology	."Nacional" clone (Ecuador)	.Rehabilitation of cocoa plantations .Intensification techniques	
Cocoa quality	.Determination of the origin of flavours .Genetic markers of technological characteristics .Development of a principle for controlling fermentation	.Choice of criteria for primary and secondary processing	.Stronger flavour .Selection assistance	.Optimization of fermentation and quality regularization (Gauthier company)

Coffee programme

Major advances have been made in genetic resources and varietal improvement for *C.arabica*, with the evaluation of Ethiopian origins, notably for their resistance to pests and diseases, which are currently being used to create F1 hybrids. Through close collaboration with BIOTROP it is now possible to propagate these F1s by somatic embryogenesis, and commercial distribution can be envisaged, subject to mastering their adaptation in the field. For the *canephora* species, the use of reciprocal recurrent selection has led to more effective utilization of the species' diversity and major genetic progress has been achieved, with the selection of high-yielding hybrid varieties. Their dissemination by seed makes them more accessible than clones to smallholders.

Access to genetic resources at the 2 breeding poles, CATIE in Central America, and IDEFOR in the Ivory Coast, is an essential coffee programme asset.

Through work carried out in partnership with NESTLE since 1994, a genetic modification technique has been mastered (BT genes against the leaf miner), which can now be extended to searching for cultivars that are resistant to major pests (coffee berry borer).

Knowledge acquired about the coffee berry borer (population dynamics, biological control) has been used to now steer control towards complementary methods such as localized chemical control, trapping and the introduction of agricultural early warning systems.

Significant progress has been made in understanding the parasite mechanisms of the main genera of nematodes (*Meloidogyne* and *Pratylenchus*) on coffee trees in Central America. Characterization of the nematode fauna has revealed the existence of substantial population diversity and confirmed the danger that certain pathotypes pose for Arabica cultivation, which will have major consequences for resistant material breeding programmes. A resistant rootstock has already been created.

The epidemiology of leaf rust in Central America suggests possible control through an early warning system. The existence of partial resistance sources in wild Ethiopian material has been confirmed.

For *C. arabica* coffee berry disease (CBD), a disease that is limited to the African continent for the time being, there is a clearer understanding of pathogen variability, notably through a joint project implemented with Kenya, Cameroon and Portugal under the RECA network. This is a prerequisite for further identification of resistance sources, which has begun in particular in the wild Ethiopian material.

Recent achievements have been obtained in soil biology. The role of endomycorrhizae on plant development and tolerance of nematodes has been discovered, and will enable the development of procedures for the acclimatization of *in vitro* plantlets and fertility management. Studies conducted on coffee-legume intercropping will make it possible to preserve soil fertility whilst reducing input consumption. A harvest estimation method has also been developed.

Socio-economic studies among smallholders have revealed the need to contribute towards the emergence of smallholder organizations, so as to propose technical solutions adapted to their constraints.

Lastly, the chemical, biochemical and sensorial characterization of cup quality is one of the basic and specific skills of the CIRAD laboratory (e.g. Robusta clones, Arabica hybrids, Ruiru 11). These tools will make it possible to continue characterizing fine or *terroir* coffees and enhance knowledge of how ecological factors, cultural practices, genotypes and post-harvest processing affect quality.

- Recap table for the coffee programme -

Projects/ disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Genetic resources and variety creation	.Assessment of the Ethiopian *Arabica* collection .RRS analyses .Mastery of genetic modification	. *C. arabica* F1 hybrids by *in vitro* culture . *C. robusta* hybrids (seeds)	.Coffee hybrids rather than clones .GM coffee trees	.NEMAYA rootstock (res. to nematodes) .2 *robusta* clones (Ivory Coast)
Integrated control (*C. arabica*)	.Knowledge of the coffee berry borer, variegated coffee bug and scale insects	.Chemical control	.Agricultural early warning systems, localized chemical control, trapping	.Rearing of 3 parasitoids
Disease control *C. arabica*)	.Epidemiology of leaf rust .Sources of resistance to coffee berry disease		.Good quality resistant varieties	
Soil -borne parasites (*C. arabica*)	.Distribution and characterization of *Meloidogyne* and *Pratylenchus* populations		.Resistant rootstocks, tolerant varieties	. NEMAYA rootstock
Study of farming systems	.N applications when intercropped with legumes .Analysis of farming systems in Laos	.Rational fertilization .Rehabilitation of coffee plantings	.Action of endomycor-rhizae in plants and nematodes	.Harvest estimation
Coffee quality	.Origin of the "potato taste" (bacterium x bug) .First results on the determinants of quality (cultivars and cultivation conditions)	.Control techniques (field and factory)	.Stabilization of coffee by centrifugation	

Coconut programme

Considerable progress has been made in understanding biodiversity, and the biomolecular approach has made it possible to differentiate between six genetically distinct groups among coconut ecotypes. In the short or medium term, the same approach will make it possible to guide breeding schemes according to genetic relationships.

The possibility of creating ortets through *in vitro* culture would be a remarkable advance, though the problems encountered with the hardening of young plants remain to be overcome.

These results confer a decisive role on the programme within the COGENT network, for which the CGRD (Coconut Genetic Resources Database) was created, along with the operation software (Coconut Data Management), and a manual for the standardization of coconut breeding techniques (STANTECH).

Studies on plant functioning indicate that early and effective selection criteria exist in the search for membrane tolerance to water constraints (lipid parameters). Chlorine nutrition is also important in reducing the effects of drought on yields.

Coconut palms are used in smallholder farming systems, and the development of architectural models of the coconut palm and of intercrops, based on a model of agrophysiological functioning and a model of economic transcription linked up to each other, is a medium-term prospect.

The development of rearing techniques for insect vectors of viral-like diseases has led to advances in etiology and epidemiology studies. However, it is in the field of lethal diseases caused by *Phytophthora* spp. that the most notable progress has been made, since treatment techniques are now known and genetic sources of resistance have been discovered.

Two new technologies are transferrable for the commercial development of coconut products: for the extraction of coconut cream, and particularly for oil extraction after hot oil immersion drying. A new technology is also very promising but requires further research prior to industrial application: enzyme-assisted coconut oil extraction.

Lastly, the programme has acquired effective experience of smallholder development through its involvement in planting or transmigration programmes in Indonesia. The researchers involved have worked on agronomic aspects, training, producer organization and rural credit.

- Recap table for the coconut programme -

Projects/disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Genetic resources and variety creation	.Genetic resources analysed by RFLP .Identification of genetic groups		.Marker-assisted selection . *in vitro* culture . Coconut Data Management software	.Coconut Genetic Res. Database . STANTECH var. impr. manual .Som. embryo-genesis protocol
Farming system functioning	.Drought markers .Chlorine nutrition		.Chlorine fertilizer	
Intercrop functioning	.Architectural models		.Architect. models of coconut palms and intercrops	
Endemic lethal rot diseases	.Vector transmission of diseases .Variety tests for *Phytophthora* .Knowledge of viroid-like mol. and *Phytomonas*	Plant transfer safety	.Tolerance and treatment against *Phytophthora*	
Commercial development of products	.Production of medium-chain triglycerides .Identification of endogenous enzymes in coconut meat.	.Hot oil immersion drying .Coconut milk production	.Enzyme-assisted oil extraction	

Rubber programme

A study of genetic resources, carried out on the collection available in the Ivory Coast, has led to the agronomic and genetic characterization of Amazon germplasm from the IRRDB international survey in 1981.

In the field of variety creation, an early selection study carried out in the Ivory Coast has led to reconfiguration of the selection scheme and implementation of veritable genotypic selection. Further downstream, monitoring of a multi-site network in five countries (Ivory Coast, Gabon, Nigeria, Cambodia, Vietnam) is providing precise knowledge of the potential of clones undergoing predevelopment.

Knowledge of new molecular markers is enabling the description of diversity in the species and highly advanced mapping of two progenies. This is a prerequisite for future marker-assisted selection.

An established somatic embryogenesis procedure has been defined, though with substantial differences in embryogenic potential from one clone to the next.

For leaf diseases, significant progress has been made for *Microcyclus ulei,* about whose genetic diversity more is now known and for which sources of resistance have been defined; for anthracnose, a control method making use of defoliation is now available. *Fomes* control has moved on to the development phase.

Decisive advances have been made in understanding the physiological mechanisms of latex flow and regeneration. Various enzymes involved in regulating the energy metabolism, in detoxification of aggressive forms of oxygen in ageing phenomena, and in nitrogen fixation, have been identified. A study of the expression of genes coding for these enzymes is providing a clearer understanding of tapping panel dryness, and a marker of response to ethylene stimulation has been identified. With all the knowledge acquired, consideration can be given to gradually improving Latex Diagnosis, a production management tool which is already widely developed in Africa and which has also been introduced in four Indonesian Agroindustrial companies.

These results also open up the way for a more effective approach to yield stimulation, taking into account new parameters for the selection of clones adapted to reduced tapping frequencies.

As regards cultivation systems, studies are continuing on competition in rubber-based farming systems with intercrops, and on improvement of the rubber-based agroforestry system in Indonesia, and new crop management sequences are proposed for new sub-optimum zones.

From a technology point of view, studies are revealing the effect of clones, and of tapping, collection and drying methods on quality and quality markers, such as viscosity and susceptibility to oxidation, are being proposed. A method has also been developed for measuring molecular sizes directly linked to rheological properties, and tools and a modelling method have been developed for rubber drying. A prototype dryer has been installed in an Ivorian plantation.

- Recap table for the rubber programme -

Projects/disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Genetic resources and variety creation	.Agron. and genetic charact. of Amazon germplasm .New breeding scheme in the Ivory Coast .Identification of clone potential at the end of selection .Mol. markers and genetic mapping .Established embryogenesis process	.Genotypic selection scheme .Prod. of *in vitro* plantlets for trials	.Marker-assisted selection	.Collection of Amazon germplasm .Clones .Creation/selection methodology .Molecular biology meth. .Methodology for clonal identification by isozymes .*In vitro* plantlet production meth.
Disease control	.*Hevea/Microcyclus ulei* interactions .Identification of resistance sources .Biology and epidemiology of anthracnose	.Anthracnose control through defoliation . *Fomes lignosus* control	.Clones resistant to *Microcyclus*	Disease control (*Fomes* and anthracnose)
Physiology of latex production	.Understanding of the physio. mechanisms of latex flow and regeneration		.Gen. markers of tapping panel dryness .Ultra-reduced tapping intensity	.Latex diagnosis .Reduced frequency tapping
Farming systems	.Performance of rubber/annual crop intercropping systems .Crop management sequences in marginal zones .Knowledge of *Hevea*-based agroforestry systems	.Crop management sequences adapted to new zones		.New crop management sequences
Rubber technology	.Technical specification characters .Effect of clones and operations on product quality .Measurement of mol. sizes linked to rheology .Modelling of drying	.Drying method	.Dryer models	

Oil palm programme

RFLP markers have been used to characterize the diversity of the American oil palm *E. Oleifera*. The creation of veritable *E. Guineensis* collections has been undertaken in Benin and the Ivory Coast and a major exchange programme is under way involving the best materials from Indonesia and Africa, in pollen and seed form.

Over the last 40 years, genetic improvement has provided genetic progress in yields amounting to around 1% per year. A similar improvement is expected in the coming years in the quality of the seeds produced by our partners in Cameroon, the Ivory Coast, Benin, Indonesia and Brazil, through the planting in 5 years of more than 1,000 ha of genetic trials, which primarily correspond to second RRS cycles, the creation of third cycle recurrent populations, parental materials, clone tests and introgression of *E. Oleifera* in *E. Guineensis*.

For disease control, 1,360 new progenies or clones have been tested with respect to *Fusarium* wilt and African research stations have improved the degree of tolerance in their seed categories intended for vascular wilt infested zones. The breeding programme for material with bud rot tolerance is being stepped up with EMBRAPA, at Manaus (Brazil).

Clone plantings that have started bearing have enabled an assessment to be made of the methods employed for choosing ortets, the degree conformity and performance levels. Molecular biology research is currently being carried out on the appearance of a variant phenotype (mantled abnormality), to determine the causes and detect it at an early stage. The development of embryonic suspensions should eventually make it possible to produce clonal material cheaply on a large scale.

In the IPM field, practical prospects are already being effectively tested against serious pests such as *Oryctes* with pheromone trapping; pheromones have also been used to estimate leaf-eating caterpillar populations and entomoviruses have been used against leaf-eating caterpillars. Decisive progress has also been made against *Chromolaena odorata* and *Mikania micrantha*, two weeds detrimental to oil palm.

In ecophysiology, major advances have been made in understanding plant functioning: leaf and root respiration, gas exchanges depending on the water vapour deficit and the soil water deficit, photosynthesis activity depending on the planting material. Models of plant functioning are now more precise. Modelling of the root system architecture and its growth carried out for one planting material can now be developed in accordance with environmental conditions and the type of planting material.

Fertilizer management in commercial plantations will now be considerably simplified with the development of a CIRAD software package.

The Drupalm® process of extracting Drupalm oil (95% palm oil and 5% kernel oil) from crushed fruits, has been technically developed and is set to meet expectations: operation of a continuous pilot unit to demonstrate its merits to potential users and disseminate this technology now remains to be done.

For the oleochemical commercial development of oil palm products, numerous laboratory studies have been undertaken and work is currently under way with Malaysia with a view to industrial development.

- Recap table for the oil palm programme -

Projects/disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Genetic resources and variety creation	.Genetic structure of breeding populations .Vascular wilt tolerance . Genetic. div. of *Elaeis oleifera* .Molecular markers of shell thickness .Embryogenic suspensions .Maturation of somatic embryos .Characterization of the mantled abnormality	.Methodology for using new *E. guineensis* populations .Varietal creation .Production of ramets for comparative trials	.Marker-assisted selection .Drought tolerant planting material .Industrial scale *in vitro* culture and artificial seeds .Molecular kit for *in vitro* detection of the abnormality	.Distribution of 2nd cycle vascular wilt resistant materials .New oil content observation technique .New seed preparation technique .Seed production management software .Cryopreservation of somatic embryo clumps
Integrated control of pests and weeds	.Characterization of the *Oryctes* pheromone . *Setothosea* and *Setora* pheromones .Entomoviruses against leaf-eating caterpillars .Introduction of pests against *Chromolaena* and *Mikania*	.Early warning systems against caterpillars .Biological control of caterpillars (Latin America and Indonesia)	.Reduction of *Oryctes* pop. by trapping	.Estimation of *Oryctes* populations .Biological control of *Chromolaena*
Little-investigated endemics	.Somatic emb. of the *E. guineensis* x *E. oleifera* hybrid and of backcrosses .Rearing of the Marchitez typanosome vector		.Distribution of tolerant backcrosses by seeds and ramets .IPM against Marchitez vectors	.Distribution of bud rot tolerant hybrids

The oil palm programme (end)

Projects/disciplines	Scientific achievements	Transferrable achievements		Transferred achievements
		Currently	Eventually	
Agrosystem functioning	.Modelling of root system architecture and growth .Carbon balance and yield model .Link between photosynthesis and VPD	.Estimation of yield potential	.Monthly and annual yield forecasts	.Mapping of zones suitable for oil palm cultivation in Africa
Agronomic assessment of plantations	.Effect of subsoiling and ameliorators in compacted soil .Characterization of oil palm plantings by remote sensing .Soil receptivity to *Fusarium* wilt	.Fertilization software combined with the GIS tool and use of satellite images	.Monitoring of events in oil palm plantings by remote sensing (nutrition, water stress, crop protection)	.Fertilizer adjustments
Oil extraction	.Drupalm process patented	.Installation of a pilot unit		
Oleochemistry and commercial development	.Medium-chain triglycerides obtained .Study of the ketonic pathway		.Installation of a pilot unit for the ketonic pathway	

Annex 2

Analysis of CIRAD-CP's fields of expertise

- Consequences for staff movements -

When drafting its five-year programming plan, CIRAD-CP endeavoured to analyse the challenges facing the tree crops covered by its mandate and reach conclusions in terms of research issues. In order to answer the research questions raised, the department will have to make scientific choices that also take into account the departments' assets, its skills, and the forces it can bring into play.

The analysis of skills carried out had four main objectives:

- assess the existing research potential
- provide an idea of how that potential will evolve in the next five years
- propose an evolution for implementation of the 5-year plan that is coherent with:

    . the choice of the department
    . existing research potential
    . funding and training possibilities

- enable the corresponding decisions to be taken in terms of job definitions, recruitment and training.

Method used

▸ The field of expertise is defined as being an activity for which the department has internationally acknowledged know-how and experience.

▸ A distinction is made between two levels:

    - overall skill, which corresponds to quite a vast area of research, e.g. a discipline, a major part of that discipline, or a multidisciplinary field (such as IPM).
    - specific skills, which are elements of the overall skill.

This study opted for the disciplinary choice for overall skill, which constitutes a basis for future analysis of multidisciplinary skills.

▸ The skills indicated are those being used in current work.

▸ They are made known through publications or commercially developed through technological achievements (processes, products, measuring instruments, etc.).

▸ Their identification should be validated by a commission from outside the department (e.g. an external review or the Human Resources Department).

Criteria adopted

Structuring of skills and their breakdown into researcher-time did not go beyond the shift. The sum of these times gives researcher-equivalents whose number is often lower than the number of researchers actually concerned by the same skill. Indeed, a researcher may have several skills indicated. This is particularly important for agronomy and varietal improvement.

The other indicators concern: degree of researcher training, age and geographical location and, lastly, internal training (for doctorates) and external training for the 1992-1997 period.

Limitations of the method

This method only partially responds to the objectives fixed, since it is reductive in that it does not take into account skills that are not involved in current operations. Nevertheless, these skills are real and can often be called upon at quite short notice. It is important to know them, so as to define possible redeployments.

In order to attenuate this drawback, a second exercise was undertaken, consisting in listing the skills corresponding to current contracts and to results obtained at an earlier date, with an index for each skill identified: (1) strong skill, (2) moderate skill and (3) weak skill.

The information provided by this method is interesting and gives an initial idea of the underlying knowledge, though it is too qualitative to be used without effective knowledge of the disciplines.

Recapitulative data

The following pages contain the tables of skills for varietal improvement, crop protection, agronomy, chemistry-technology and biometrics, cross-referenced to the programmes (tables 1, 2, 4, 5, 6).

Cross-referenced researcher-equivalent/age, training and geographical location data are then given (tables 3,7,8,9)

For agronomy and plant breeding, a larger number of researchers than for the other disciplines enabled a fuller analysis to be carried out (table 3)

Discussion and conclusions

Plant breeding (tables 1 and 3)

In terms of researcher numbers, the strengths of the department lie in varietal creation (15.25 researcher-eq) and *in vitro* culture (9.5 researcher-eq). The first skill covers the five plants of the department, and its potential will be maintained, possibly re-examining the relevance of where the researchers are located. The second constitutes an undeniable asset for the department, for clone dissemination, but also because it opens up the way for genetic modification.

Molecular biology (5.0 researcher-eq)[1] is currently one of the priority research aspects of the discipline, since it prepares the way for marker-assisted selection, which is set to become an essential tool in varietal creation. In particular, this tool is expected to provide true progress in the genetic control of diseases such as cocoa black pod rot and of *Microcyclus ulei*.

Genetic modification (2 researcher-eq) involves two plants, coffee and *Hevea*, and is set to be extended to the others, since this technique, in addition to the dissemination of new varieties, will make it possible to study basic physiological phenomena.

The department is well placed in germplasm management (3.75 researcher-eq) for coconut, *Hevea*, cocoa and coffee (in conjunction with ORSTOM); this could be an important point of access in the future global agricultural research system.

Despite the hazards, seed production and management remain among the department's strengths, notably for oil palm. Thought needs to be given to the possibilities of once again clearly making this skill known, with a view to commercial exploitation.

The average age, 40.0 years, is the lowest of the the disciplines in the department and varies from 36 years for coffee to 42 for oil palm. The expatriation rate is 45.9, which is quite high given that expatriation primarily concerns varietal creation and seed production (20 researchers).

In brief, the aim of the department is to maintain the potential for varietal creation, if necessary with geographical redeployments, strengthen biotechnologies despite the problems posed by the new policy of research grant holder supervision (currently 4 researchers) and strengthen the links between "conventional" and "molecular" breeders.

In the field of germplasm management, the department will require greater knowledge in biometrics for the development and management of data bases.

Agronomy (tables 2 and 3)

The basic strengths lie in the overall skill of "cultivated land management" and within that overall skill, in the specific skills of "crop techniques" and "plantation assessments", in fact in what is often called general agronomy.

On the other hand, CP's acknowledged strong points, namely plant physiology and ecophysiology, have a comparatively quite low researcher potential. Specialization is strong (80% of the researchers have written a thesis) and the expatriation rate is similar to the other agronomy specializations.

Likewise, intercropping only involves 1.5 researcher-eq, whereas it is a decisive aspect for smallholdings.

As regards agricultural economics, in the broad sense, since there is no real work under way on farm economics, it is represented by fewer than 2 researchers.

The general recommendation of the external review was to re-centre research on smallholdings and, for agronomy, to strengthen ecophysiology, but gearing work towards models to assist in decision-making, by studying the effects of crop management sequences on yield elaboration.

---

[1]- 2 to 3 researchers from BIOTROP who are working on tree crops, notably cocoa, should also be added to this potential.

The farm and economic aspects[2] will also need to be taken into account in such an approach.

The aim is therefore to strengthen at least three areas of agronomy: ecophysiology, the study of intercropping systems, and agricultural economics.

Internal redeployment possibilities are limited, since the average ages for the two specific skills "plantation assessments" and "crop techniques" are 51 and 47 years respectively (but with standard deviations of 7 and 9), but also because they are activities that respond to a demand and generate contractual resources. However, they are desirable and possible, at least for intercropping and ecophysiology.

For agricultural economics, it can undoubtedly be hoped that support will come from the TERA department, but the resources of that department are also insufficient. Moreover, a solid partnership between the two departments can only be established if CP has its own forces within that discipline.

Priority therefore needs to be given to recruiting in the agricultural economics and systems agronomy fields.

Crop protection (table 4)

The situation is relatively contrasting: in plant pathology and nematology, the researchers are divided up quite evenly between the crops (including virologists from the AMIS department), the average age is rather low and the expatriation rate high (72.7%).

For pest studies, most of the staff are working on oil palm and coconut and, in the expatriate context, work is mostly concentrated on three crops: the two already mentioned plus coffee. The average age is easily higher and the expatriation rate lower.

In these two disciplines, the rate of researchers with a doctorate is higher than the departmental average.

If reference is made to the choices of the department, it can be seen that staff numbers are insufficient to completely fulfil them. In plant pathology, the departure of a researcher from Cameroon to a "Crop Protection" programme in Montpellier has made redeployment or recruitment necessary for an East Africa project and for the corresponding studies on CBD and tracheomycosis.

For cocoa pests, there are no more researchers currently working in the field, though the mirid problem remains a major limiting factor.

Chemistry and Technology (table 5)

Following the departure of the oils and fats chemistry laboratory to the AMIS department, the team appears well diminished: 10 people for four export crops, whose products are only used after complicated processing. In addition, the expatriation rate is low (2 researchers), which also does not correspond to the importance accorded to post-harvest processing for the quality of certain products (notably coffee and cocoa). One crop, coconut, no longer has a full-time researcher.

2- In the current economic context, flexibility in crop management sequences is also a requirement for more effectively responding to market fluctuations.

However, the team compensates for its small size through its high level of technical know-how and a good distribution of its activities with, on the other hand, a rather high average age and a certain degree of dispersion.

In order to achieve the department's objectives, activities will have to be stepped up in the field for post-harvest processing in the smallholder environment, and in the laboratory for quality analysis (coffee and cocoa flavour, rubber rheology).

Biometrics (table 6)

Despite its skills, the current team will not be able to ensure an appropriate development of its modelling, germplasm management and spatial analysis operations. Back-up from the "Agronomy" programme and strengthening of staff numbers will be required.

Economics

The department has lost all its skills in the economic analysis of commodity channels, with the departure of two specialists to the EPM programme. It seems difficult for the department to work within the "commodity channel" context and develop the social sciences without having a minimum amount of knowledge of the commodity channels in which it is required to work.

Researcher training (tables 7,8,9)

The share of researchers with a thesis is quite high, and above the CIRAD average, since it borders on 50% for the department as a whole and reaches 64% for the rubber programme and 60% for crop protection. That probably explains why internal training for this field has been quite low (13 theses in 5 years), though five authorizations to supervise thesis work have been defended (four for technology and one for varietal improvement).

As regards PhD training for researchers from overseas, the figure remains modest and two disciplines - varietal improvement and crop protection - account for 60% of the training. For training courses, it is technology that alone accounts for 50% of the training.

Training is to be revised in line with operations organized by the central service.

Recap tables

Table 1: Fields of expertise in Plant Breeding (men/year)*

Fields of expertise		Programmes					Total	%
Overall skills	**Specific skills**	**Cocoa**	**Coffe e**	**Coconut**	**Rubber**	**Oil Palm**		
Genetic resources	.Survey, management and *in situ* preservation	0.50		0.25	0.50		1.25	
	.Preservation *ex situ*			0.25		0.25	0.50	
	.Diversity studies	0.50		1.00	0.50		2.00	
Total genetic resources		1.00		1.50	1.00	0.25	**3.75**	**9%**
Varietal improvement	.Varietal creation and breeding	3.00	2.75	1.50	2.75	5.25	15.25	37
	.Biometrics. IT	0.25	0.25	0.50	0.25	0.25	1.50	
	.Whole plant biology			0.50		0.25	0.75	
	.Biology of reproduction	0.50			0.25		0.75	
	.Mapping. marker-assisted selection	1.50	0.25		1.25	2.00	5.00	12
	.Cytology-cytogenetics				0.25		0.25	
	.Genetic modification		1.25		0.75		2.00	
Total varietal improvement		5.25	4.50	2.50	5.50	7.75	**25.5**	**61%**
Distribution of genetic progress	.Seed management and production			0.25	0.25	2.25	2.75	
	.Micropropagation	1.25	1.5	0.75	3.25	2.75	9.50	23
Total distribution of genetic progress		1.25	1.50	1.00	3.50	5.00	**12.25**	**30%**
General total		7.5	6	5	10	13	41.5	100%

(*) research grant holders are counted in the skills table (2.25 for mapping and 1.75 for micropropagation) but not in the calculation of the other indicators (age, diploma, expatriation)

Table 2: Fields of expertise in agronomy (men/year)

Fields of expertise							Total	%
Overall skills	**Specific skills**	**Cocoa**	**Coffe e**	**Coconut**	**Rubber**	**Oil palm**		
Functioning of the plant and of the stand	.Biochemistry				3.50		3.50	7
	.Histochemistry				1.00		1.00	2
	.Photosynthesis	0.75		0.50		0.75	2.00	4
	.Root system			0.50	0.75		1.25	3
	.Modelling		0.25	0.25			0.50	1
Total FPS		0.75	0.25	1.25	5.25	0.75	**8.25**	**17%**
Environmental factors and conditions	.Soil science					0.50	0.50	1
	.Mineral nutrition	0.50	0.50	1.50		2.00	4.50	10
	.Water-soil-plant			0.50		0.50	1.00	2
	.Soil microbiology		0.75				0.75	2
Total EFC		0.50	1.25	1.50		3.00	**6.25**	**15%**
Cultivated land management	.Intercropping	0.25	0.75	0.50			1.50	3
	.Development	0.50	2.00	1.75	1.00	0.50	5.75	12
	.Plantation assessment	0.25	0.75	1.75	1.75	2.75	7.25	15
	.Management	1.25	0.25	0.50	1.25	1.00	4.25	9
	.Cultural techniques	3.00	0.50	0.25	4.75	2.50	11.0	23
	.Remote sensing					0.50	0.50	1
Total CLM		5.25	4.25	4.75	8.75	7.25	**30.25**	**63%**
Agricultural economics	.Comm. channel		0.50				0.50	1
	studies	0.50	0.25				0.75	2
	.Farming systems		0.50				0.50	1
	.Technology transfer							
Total agricultural economics		0.50	1.25				**1.75**	**4%**
Overall total		7	7	8	14	11	46*	100%

(*) research grant holders, national service volunteers and senior technicians are included

Table 3: Fields of expertise and average age of researchers (agronomy and plant breeding)

Fields of expertise		Men/year	Number of researchers involved	Average age
Overall skills	**Specific skills**			
AGRONOMY				
Functioning of the plant and of the stand		8.25	11	37.7
Environmental factors and conditions		6.25	14	48.2
Cultivated land management		30.25	37	47.5
	Intercropping	1.5	5	37.8
	.Development	5.75	14	51.2
	.Plantation assessment	7.25	21	51.6
	.Management	4.25	10	48.6
	.Crop techniques	11.00	19	46.6
	.Remote sensing	0.50	1	59.0
Agricultural economics		1.75	4	42.7
Total Agronomy		46*		46.2**
PLANT BREEDING				
Genetic resources		3.75	8	38.8
Varietal improvement		25.5	31	40.6
	.Varietal creation & selection	15.25	25	41.5
	.Biometrics and IT	1.50	5	42.0
	.Whole plant biology	0.75	2	44.0
	.Biology of reproduction	0.75	2	44.0
	.Mapping. M.A.S.	5.00	9[2]	36.8
	.Genetic modification	2.00	4	37.5
Distribution of genetic progress				
	.Seed management and production	2.75	8	41.8
	.Micropropagation	9.50	14	37.5
Total plant breeding		41.5*		40.0**

(*) including national service volunteers, temporary contracts and research grant holders
(**) not including national service volunteers, temporary contracts and research grant holders

Table 4: Fields of expertise in crop protection (men/year)

Fields of expertise		Programmes				Total	%
Overall skills	**Specific skills**	**Cocoa**	**Coffe e**	**Rubber**	**Oil palm and coconut**		
Mycology	.*Phytophthora* spp	2,75			0.25	3	
	.Vascular wilt				0.75	0.75	
	.Rust		1.00			1	
	.C.B.D.		1.50			1.5	
	.Witches' broom	0.75				0.75	
	.*Microcyclus*			1.25		1.25	
	.*Colletotrichum*			1.00		1	
	.*Fomes*			1.00		1	
Total mycology		3.5	2.5	3.25	1	**10.25**	**52%**
Virology*					(2.00)*		
Nematology			1.00			**1**	**5%**
Entomology	.Coffee berry borer		1.00			1	
	.Knowledge of pests	1.50			4.00	5	
	.Ecology and chem. of insects				1.00	1	
	.Vector insects				1.00	1	
Total entomology		1.5	1		6	**8.5**	**43%**
Overall total		5	4.5	3.25	7	19.75	100%

(*) skills in the "biological bases of integrated protection" programme of the AMIS department

Table 5: Fields of expertise in chemistry and technology (men/year)

Fields of expertise		Programmes				Total	%
Overall skills	**Specific skills**	**Cocoa**	**Coffee**	**Coconut and oil palm**	**Rubber**		
Chemistry	.Oils and fats*						
	.Flavours	0,75	0,25			1	10
	.Polymers				2,00	2	20
	.Phenolic compounds	0,25	0,50			0,75	6
	.Others		0,25		0,25	0,5	4
Total chemistry		1,00	1,00		2,25	**4,25**	**40%**
Technology	.Sensorial analysis	0,25	0,75			1	10
	.Post-harvest tech.	1,00	0,25		0,25	1,5	14
	.Tech. of processed product				0,75	0,75	6
	.Equipment design			0,50	0,25	0,75	6
	.Management of processing centres				1,00	1	10
	.Appraisal						
	.Others	0,25	0,50	0,50	0,25	1,5	14
					0,25	0,25	2
Total Technology		1,50	1,50	1,00	2,75	**6,75**	**60%**
Overall total		2,50	2,50	1	5	11	100%

(*) Skills in the AMIS department (oils and fats chemistry laboratory)

Table 6: Fields of expertise in Biometrics* (men/year)

Fields of expertise		Programmes					Total
Overall skills	**Specific skills**	**Cocoa**	**Coffe e**	**Coconut**	**Rubber**	**Oil palm**	
.Trials	. Experimental designs	0.25	0.25	0.25		0.25	1
	. Trial analysis	0.25	0.25	0.50		1.00	2
		0.25	0.25	0.50		0.50	1.5
.Quantitative genetics	.Epidemiology and agro-physiology					0.50	0.5
.Sampling		0.25		0.25		0.50	1
.Modelling	.Plant architectures						
			0.25				0.25
						0.25	0.25
.Spatial analysis and GIS	Spatial statistics.		0.25		0.25		0.50
.Quality control							
.Data bases				1.00		1.00	2
Overall total		**1**	**1.25**	**2.5**	**0.25**	**4**	**9**

(*) researchers (5) and technicians (4)

Table 7: Distribution of senior scientific staff according to training

Overall skills	Programmes					Total	% disc.
	Cocoa	Coffee	Coconut	Rubber	Oil palm		
Plant breeding							
Engineer			1		3	4	10.9
DAA/DEA/DESS*	3	4	3	3	2	15	40.5
Doctorate	4	2	2	4	6	**18**	**48.6**
Crop protection							
Engineer			1			1	5.0
DAA/DEA/DESS	1	2	2	1	1	7	35.0
Doctorate	4	2	2	3	1	**12**	**60.0**
Agronomy							
Engineer	4	5	4	2	8	23	54.8
DAA/DEA/DESS			1	1		2	4.8
Doctorate	1	3	3	7	3	**17**	**40.4**
Chemistry and Technology							
Engineer	1	1		1	1	4	40.0
DAA/DEA/DESS				1		1	10.0
Doctorate	2	1		2		**5**	**50.0**
Biometrics							
Engineer						2	50.0
DAA/DEA/DESS						2	50.0
Doctorate							
Total all programmes**							
Engineer	6	6	6	3	13	34	30.1
DAA/DEA/DESS	5	6	7	6	3	27	23.9
Doctorate	11	8	7	16	10	**52**	**46.0**
% in each programme							
Engineer	27.2	30.0	30.0	12.0	44.8		
DAA/DEA/DESS	22.8	30.0	35.0	24.0	20.7		
Doctorate	**50.0**	**40.0**	**35.0**	**64.0**	**34.5**		

(*) Advanced diplomas
(**) with researchers involved in research management

Table 8: Overall skills, average age, doctorate training and expatriation rate

Overall skills	Number of researchers involved*	Average age of the researchers	Expatriation rate	Theses %
Plant breeding	37	40.0	45.9	48.6
Crop protection				
- Plant pathology - nematology	11	41.0	72.7	63.6
- Entomology	9	51.3	55.5	55.5
Agronomy				
- Functioning of the plant and of the stand	10	39.0	40.0	80.0
- Environ. factors and conditions	14	48.2	35.7	42.8
- Cultivated land management	37	47.5	43.2	27.0
- Agricultural economics	4	42.7	75.0	0
Chemistry	4	45.2	25.0	75.0
Technology	6	49.0	16.6	16.6
Biometrics	5	40.5	0	20.0

(*) a researcher may appear under several headings (primarily for plant breeding and agronomy)

Table 9: Department involvement in training (1992-1997 period)

Programmes/ disciplines	Theses			Dissertations (DEA, DESS, etc)	Trainees	
	CP researchers	Researchers from overseas	Research grant holders (MENRT)*		French	Foreign
COFFEE						
Breeding	1	2		2	2	
Crop protection		4	1	6	4	2
Agronomy	2			1		1
Technology		1	1	5	3	2
Economics	1					
Biometrics				3		
COCOA						
Breeding		3	2	1		1
Crop protection	1	2	1	3	1	2
Agronomy			2	1	1	
Technology			1	4	3	5
Biometrics				3		
COCONUT						
Breeding	1					2
In vitro culture	1		1	6		10
Crop protection			1	4	2	
Agronomy	3	3		3	1	3
Technology		1	1	7		10
Biometrics				1		
RUBBER						
Breeding			1	1	3	9
In vitro culture			2	2	1	4
Crop protection			1	1	2	5
Agronomy	2		2	4		8
Technology	1		2	1	15	15
OIL PALM**						
Breeding			3	5	6	
Crop protection		2	3			
Agronomy			1		1	
Oleochemistry		1	6	5	18	15
Biometrics				5		
Total per discipline						
Breeding	2	5	6	9	11	12
Crop protection	1	8	7	14	9	9
In vitro culture	1		3	8	1	14
Agronomy	7	3	5	9	3	12
Technology	1	2	5	17	21	32
Oleochemistry		1	6	5	18	15
Economics	1					
Biometrics				12		
Total per programme						
Coffee	4	7	2	17	9	5
Cocoa	1	5	6	12	5	8
Coconut	5	4	3	21	3	25
Rubber	3		8	9	21	41
Oil palm		3	13	15	25	15
Overall total	13	19	32	74	63	94

(*) French Ministry for National Education, Research and Technology
(*) + 4 authorizations for the supervision of thesis research in oleochemistry and 1 in plant breeding

Annex 3

CIRAD-CP staff numbers and location of senior scientific staff

‣Number of senior scientific staff members per programme and per discipline (1st January 1998).

Disciplines	Programmes				
	Cocoa	Coffee	Coconut	Rubber	Oil palm
Plant breeding	7	6	5	6	12
Crop protection	6	4	6	4	1
Agronomy	6	6	7	9	9
Chemistry-Technology	3	2		4	1
Research management	2	1	2	1	1
Total	24	19	20	24	24
Expatriation rate (%)	50.0	52.6	35.0	50.0	50.0

‣Current scientific back-up within CIRAD

Programmes/disciplines	Other CP programmes or biometrics unit	AMIS programmes
COCOA		
Plant breeding		3
Crop protection	1	
Chemistry-Technology		2
Biometrics	1	
COFFEE		
Plant breeding	1	1
Crop protection	2	1
Agronomy	1	
Chemistry-Technology	1	
Biometrics	1	
COCONUT		
Plant breeding		
Crop protection	3	
Agronomy	1	1
Chemistry-Technology	1	2
Biometrics	1	
Economics		1
RUBBER		
Agronomy		1
OIL PALM		
Plant breeding	2	
Crop protection	5	1
Agronomy	3	3
Chemistry-Technology		3
Biometrics	3	
Economics		2

▸ **Location, scientific host organization and budgets of senior scientific staff**

Table 1: Cocoa and Coffee Programmes

Locations	Cocoa			Coffee		
	Number	Organization	Budgets	Number	Organization	Budgets
Mainland France						
Montpellier	12	CIRAD	BCRD*	8	CIRAD	BCRD
Other				1	Nestlé	BCRD
Africa						
Cameroon	2	IRAD OCQ	ATD OCQ			
Ivory Coast	1	IPGRI/IDEFOR	BCRD	1	IDEFOR	BCRD
Sao Tomé	2	Poto project	BCRD CFD			
Tanzania				1	Minagri	UE
America						
Costa Rica				2	PROMECAFE	BCRD BCRD
Guatemala				1	CATIE	BCRD
Honduras				1	PROMECAFE	BCRD
Salvador				1	PROMECAFE	BCRD
Dominican Rep.				1	PROMECAFE	BCRD
Trinidad	2	CR Un.	BCRD		EPROMECAFE	
Ecuador	2	ECU-B7 project	1 BCRD 2 EU			
Fr. Guiana	1	CIRAD	BCRD			
Asia & Oceania						
Laos				1	Minagri	BCRD/CFD
New Caledonia				1	CIRAD	BCRD
Pap. New Guinea	1	CCRI	BCRD			
Vanuatu	1	VARTC	BCRD			

(*) BCRD = Civil Research and Development Budget

Table 2: Coconut and Rubber Programmes

Locations	Coconut			Rubber		
	Number	Organizations	Budgets	Number	Organizations	Budgets
Mainland France						
Montpellier	11	CIRAD & ORSTOM	BCRD	12	CIRAD	BCRD
	1	BUROTROP	BCRD			
Others	1	INRA	BCRD			
Africa						
Ivory Coast	1	IDEFOR	BCRD	3	IDEFOR	2 BCRD 1 ORSTOM
Gabon				2	CATH	ATD RP
America						
Brazil				1	EMBRAPA	BCRD
Guatemala				1	Gr. de huleros	BCRD
Fr. Guiana	1	CIRAD	BCRD	1	CIRAD	BCRD
Asia & Oceania						
Indonesia	2	TBS ICRAF	RP BCRD			
Pap. New Guinea	2	CCRI	BCRD RP			
				3	Mahidol Uni.	BCRD
Thailand	1	VARTC	BCRD			
Vanuatu				1	GRC/TRC	RP
Vietnam						

Table 3: Oil Palm Programme and recap for CIRAD-CP

Locations	Number	Organizations	Budgets	Total for department
Mainland France				Mainland France: 58 (52.2%)
Montpellier	11	CIRAD & ORSTOM	10 BCRD 1 ORSTOM	
	1	CIRAD	BCRD	
Africa				Africa: 19 (17.1%)
Cameroon	2	IRAD SOCAPALM	BCRD RP	
Ivory Coast	4	IDEFOR	BCRD	
America				America: 17 (15.3%)
Brazil	2	EMBRAPA	BCRD	
Asia				Asia and Oceania: 17 (15.3%)
Indonesia	4	2 IOPRI SOCFINDO PT SMART	BCRD BCRD RP	

▸ CIRAD-CP Staff (as of 1st March 1998)

Staff	Total	Cocoa	Coffee	Coconut	Rubber	Oil palm
Programmes						
.Senior scientific staff	111	24	19	20	24	24
.Technicians						
-Montpellier	17	3	4		8	2
-Fr. Guiana	9	3		3	3	
.Assistants	18	3	2	2	6	5
Management						
. Senior staff	7					
.Assistants	6					
Management service						
.Senior staff	3					
.Assistants	14					
Total senior staff	121					
Total other staff	64					
Overall total	185					

Annex 4

List of CIRAD-CP projects by major themes

▸ **Knowledge and improvement of smallholder farming systems in the humid tropics**

- Sustainability of cocoa-based farming systems in Africa.

- Improvement of *C. canephora* (robusta)-based farming systems from West Africa.

- Improved competitiveness of coconut cultivation in major production zones.

- Support for the diversification of coconut uses.

- Analysis, diagnosis and design of farming systems adapted to smallholdings.

- Support to smallholdings integrating oil palm in Africa.

Productivity improvement and tree crop intensification

- Sustainable exploitation of *C. arabica* in intensified farming systems of Central America.

- Improvement of tapping output, adaptation of planting material and planting techniques.

- Sustainable intensification factors in oil palm plantings.

▸ **Limiting factors due to diseases and pests**

- Integrated control of *Phytophthora* black pod rot in cocoa.

- Improvement of coffee trees in East Africa through management of the major phytosanitary constraints.

- Genetic control and trapping to control coffee berry borer populations.

- Integrated control of coconut Lethal Yellowing disease: case of the Mexico-Caribbean zone.

- Study of *Hevea/Microcyclus ulei* interactions for the creation of resistant planting material.

- Integrated control of oil palm bud rot in Latin America.

▸ **Quality issues**

- Revival of fine cocoas in America.

- Knowledge and mastery of cocoa quality chains.

- Control and reduction of variability in natural rubber quality.

Somatic embryogenesis and genetic modification

- Development of somatic embryogenesis and genetic modification methods for *Hevea*.

- Mastery of somatic embryogenesis for oil palm.

Centre
de coopération
internationale
en recherche
agronomique
pour le
développement

Tree
Crops
Department
CIRAD-CP

Parc scientifique
Agropolis III
BP 5035
34032 Montpellier
Cedex 1
France