# The role of international cooperation in the development of biotechnology in coconut

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## 1. Introduction

The coconut is an important smallholder crop that has strategic value for developing countries. It significantly contributes to food security, improved nutrition, employment and income generation. In many Asia-Pacific countries, it accounts for 15% to 50% of export earnings. The coconut has high potential for food, shelter, industrial, pharmaceutical and energy uses and for environmental protection. It can be grown economically in harsh environments and could promote sustainable farming systems in otherwise fragile coastal, island/atoll and hilly ecosystems.

Despite its tremendous potential in supporting developing countries, the coconut industry is beset by many problems, the major ones of which are low productivity and unstable markets. OIL WORLD estimates that world copra yields have been decreasing in the last 20 years. It was 720 kg of copra per hectare in 1976; 430 kg in 1984; and 400 kg in 1992 (Frison *et al.*, 1993). Production decline despite increasing hectareage is due to ageing of palms, pests, diseases, natural calamities and lack of high-yielding varieties. The same estimate predicts that among the oils and fats, coconut oil will play a declining role. By the year 2008-12, a disappearance of 3.3 million MT annually or 2.5% of all oils and fats is projected. Yields are fluctuating in cycles of 2-5 years due to biological and climatic reasons, consequently eroding market confidence in stability of supply. Unless the production problems are addressed, the coconut farmer and the coconut industry will suffer.

## 2. Major coconut production problems

There are three major constraints to sustainable world coconut production, namely: 1) lack of adapted, high-yielding varieties in good quantities; 2) low level of yield security; and low farmer productivity.

### *2.1. Lack of adapted, high-yielding varieties in good quantities*

Many coconut-producing countries do not have the capacity to develop improved varieties and hybrids. Several strong national coconut research programmes have developed high-yielding varieties that could increase yields by as much as 400-600%, but these could not be shared with other countries for testing or commercial planting due to the lack of affordable and efficient disease indexing protocols or indexing capability of many national programmes or other protocols as bases for informed quarantine decisions. The problem lies in the fact that several of the pathogens are quite difficult to detect by traditional methods. Thus, more sensitive, rapid and cost-effective methods of detection which are suitable to developing countries need to be developed and disseminated for pathogen characterisation, testing and germplasm health certification. Biotechnology can offer possibilities for alleviating this problem.

Several varieties and hybrids developed by strong national programmes with assistance from international organisations have good yield potentials under good soils and high levels of management. However, many of these materials lack the adaptation under resource-poor farmer, smallholder conditions and the resistance to major diseases and abiotic pressures such as strong winds. It is understandable that all these characters cannot be incorporated into a single variety because of lack of tools for rapidly identifying these characters and for understanding the genetic basis of inheritance. Recent techniques in biotechnology offers some potential tools for undertaking this work.

It takes a long time to multiply a suitable variety or hybrid for commercial planting. For example, about one hectare of hybrid seed garden is needed to plant an average of 50 hectares per year. This multiplication rate is too low if national programmes were to engage in massive replanting. Due to this low multiplication rate, the final cost of planting materials would be unaffordable to resource-poor farmers unless governments provide a subsidy which many countries cannot afford. Recent developments in biotechnology, particularly somatic embryogenesis, offer tremendous potential for rapidly producing reasonably-priced planting materials.

### *2.2. Low level of yield security*

With the present varieties, yield security cannot be guaranteed due to constant threat posed by infectious diseases and pests, adverse calamities such as typhoons, cyclones and drought, and genetic erosion. For example, it is estimated that over 30 million coconut palms have been killed by the cadang-cadang disease in the Philippines and the lethal yellowing disease caused by phytoplasma pose the greatest threat to coconut growing in the future since there are no economic control measures (Mielke, 1994). Large areas have been devastated by the latter disease and additional areas are at risk, making it one of the biggest disincentives to new coconut plantings. *Phytopththora* disease has caused considerable damage in many coconut-producing countries of the world. Traditional chemical control methods do not work, but even assuming that they do, costs would be prohibitive to the coconut farmer, apart from the environmental damage it would cause.

Genetic diversity is a major factor that determines yield security in the future. A lot of coconut diversity which contain the desirable genes for developing better varieties have been lost through planting of hybrids with narrow genetic base, high pest and disease pressures, natural calamities, urbanisation and acute need for coconut lumber in the housing industry due to depleted forest resources. There is a need to urgently locate, collect and evaluate these precious genetic materials and to conserve them before they are forever lost.

Traditional methods of locating and evaluating diversity using morphometric parameters are often inadequate, leading to unusually large amount of duplicates that unduly increase conservation costs. The use of biotechnology, in particular, molecular markers, offer potential for more precision, resulting in more accurate and economical characterisation of diversity. The same technique can be used to evaluate genetic integrity in conserved and propagated materials and in more efficiently selecting suitable parents for breeding improved varieties.

### *2.3. Low farmer productivity*

Low farmer productivity is a problem because it determines whether a farmer will plant coconut or even maintains his planting. It also determines whether he will invest to obtain more yield. The use of high-yielding varieties is one way of increasing his productivity. However, even if a suitable variety were developed, it would probably be beyond his reach due to the high cost of seed multiplication and the limited quantities available. Biotechnology research is urgently needed to increase the efficiency of multiplication and to assess the genetic integrity of the propagated material.

Farmer productivity can also be increased by developing high-value products as alternatives to copra and coconut oil and by identifying suitable germplasm for these products and using them in breeding work. Biotechnology could also be used as a breeding tool to tailor-fit varieties to specific growing conditions and product preferences. Examples of biotechnology applications are in the breeding for drought tolerance to increase productivity in dry rainfed areas; lethal yellowing disease tolerance to resuscitate many coconut areas devastated by the LYD and expand planting in more areas of Africa, Latin America and the Caribbean; and breeding for high lauric oil content to increase crop efficiency in the production of premium-priced medium chain fatty acid.

## 3. The COGENT research agenda and the role of biotechnology

### *3.1. Background of COGENT and its mandate*

The coconut is beset by many problems that affect the incomes of poor coconut farmers, the major ones being low farm productivity and unstable markets. There is an urgent need to address these problems through research. However, by its very nature, coconut requires long-term research programmes, with assured organisation and funding support that many national programmes cannot reliably provide without international assistance.

This problem was recognised by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) in 1986 in its review of CGIAR priorities and strategies, which led to the identification and prioritisation of five research areas requiring international support:

a. Germplasm collecting, conservation, evaluation and enhancement.
b. Control of diseases and pests, especially the lethal diseases.
c. Productivity and sustainability of coconut-based agroforestry systems.
d. Improving the efficiency and value-added benefits in post harvest processing and utilisation.

e. Socio-economic issues influencing farmers' participation in rehabilitation and replanting.

Resource constraints led to activities based on the first priority. At the suggestion of the TAC/CGIAR, at an international workshop on coconut genetic resources in Cipanas, Indonesia in October 1991, representatives of 15 coconut-producing countries recommended establishing an international coconut genetic resources network. With the endorsement of the CGIAR and its donors, the International Plant Genetic Resources Institute (IPGRI) established the International Coconut Genetic Resources Network (COGENT) in 1992 to promote an international collaborative programme on coconut genetic resources conservation and use. Subsequently, IPGRI established the COGENT secretariat and the Steering Committee and later incorporated COGENT into its research programme. Thus COGENT is supported by IPGRI in its capacity as organiser and executing agency, and by partner institutions and donors.

In implementing the project, the networking approach was adopted due to the fact that only a few coconut national programmes had strong research capability.

**Table 1.** Current and prospective COGENT Member Countries.

| Southeast and East Asia | South Asia | South Pacific | Africa/Indian Ocean | Latin America/ Caribbean |
|---|---|---|---|---|
| 1. China | 1.Bangladesh | 1. Cooke Is. | 1. Benin | 1. Brazil |
| 2. Indonesia | 2. India | 2. Fiji | 2. Cote d'Ivoire | 2. Costa Rica |
| 3. Malaysia | 3. Pakistan | 3. Kiribati | 3. Ghana | 3. Cuba |
| 4. Myanmar | 4. Sri Lanka | 4. Papua New Guinea | 4. Kenya | 4. Guyana |
| 5. Philippines | | 5. Solomon Is. | 5.Mozambique | 5. Haiti |
| 6. Thailand | | 6. Tonga | 6. Nigeria | 6. Jamaica |
| 7. Vietnam | | 7. Vanuatu | 7. Seychelles | 7. México |
| | | 8. Samoa | 8. Tanzania | 8. Trinidad- Tobago |
| **Prospective members** | | 9. Tuvalu | 9. Comoro | 9. Colombia |
| | | 10. Marshall Is. | 10. Madagascar | 10. Domin. Rep. |
| | | | | 11. Ecuador |
| | | | | 12. El Salvador |
| | | | | 13. Guatemala |
| | | | | 14. Panama |
| | | | | 15. Venezuela |

The objectives of COGENT are:

a. To promote through COGENT the collaboration between coconut-producing countries and partner institutions in the conservation and use of coconut genetic resources and in strengthening the capacity of national and regional programmes to conduct research.
b. To co-ordinate activities of national, regional and global significance in germplasm exploration, collecting, safe exchange, conservation, enhancement, evaluation and utilisation.
c. To establish a basis for collaboration on the broader aspects of coconut research and development.
d. To utilise the results of research to promote socioeconomic and environmental benefits to coconut farmers and coconut-producing countries.

To date, COGENT has 35 coconut-producing member countries (Table 1), with five fully operational regional sub-networks, namely: Southeast and East Asia, South Asia, South Pacific, Africa/Indian Ocean, and Latin America /Caribbean.. By 1998, the network will be implementing 81 country research projects.

### *3.2. COGENT research and training agenda and biotechnology needs*

COGENT has six research agenda items, all of which require international cooperation to be effective. I will enumerate these and discuss the biotechnology research needs to promote further efficiency in carrying out the research activities.

#### *3.2.1. Network coordination and capacity building*

The development of biotechnology capability in selected member countries of COGENT is key to effective genetic conservation and use. For the next three years, training in molecular markers to locate and characterise diversity and to characterise pathogens has been scheduled through the assistance of the Asian Development Bank and the Common Fund for Commodities. To be effective in this task, there is a need to catalyse the participation of advanced laboratories in developed and developing countries.

#### *3.2.2. Information and documentation*

Through the assistance of the French Government and CIRAD, COGENT has embarked on the development of an international coconut database to provide coconut breeders with information which they could use to efficiently select genetic materials for breeding. To date, the database has information (passport and characterisation data) on 936 accessions conserved in 20 sites in 17 countries (Table 2). The characterisation data is based on morpho-agronomic parameters that are inadequate. Biotechnology techniques are needed to more efficiently characterise this diversity and to provide more information on the nature of diversity in these materials.

**Table 2.** COGENT coconut germplasm collections with passport and characterisation data incorporated in the international coconut genetic resources database.

| Country | Site | No. of Accessions |
|---|---|---|
| 1. India | CPCRI/Kasaragod | 194 |
| 2. Sri Lanka | Coconut Research Institute/ Lunuwila | 49 |
| **Total for South Asia** | | **243** |
| 3. Indonesia | Bone Bone Expt. Garden/S. Sulawesi<br>Mapanget Expt. Garden/N. Sulawesi<br>Pakuwon Expt. Garden/W. Java | 41<br>39<br>24 |
| 4. Malaysia | MARDI/Hilir Perak | 44 |
| 5. Philippines | Philippine Coconut Authority/ Zamboanga | 121 |
| 6. Thailand | Chumphon Hort. Station | 20 |
| 7. Vietnam | Dong Go Expt. Center | 20 |
| **Total for Southeast Asia** | | **309** |
| 8. Fiji | Coconut Centre/Taveuni | 11 |
| 9. Papua New Guinea | CCRI/Keravat<br>Jim Grose Research Station/Madang | 3<br>53 |
| 10. Vanuatu | Coconut Research Station/Saraoutou | 37 |
| 11. Western Samoa | MAFF, Apia | 9 |
| **Total for South Pacific** | | **113** |
| 12. Benin | Coconut Research Center/Seme Podji | 4 |
| 13. Côte d'Ivoire | Station Cocotier Marc Delorme/Port Bouet | 99 |
| 14. Tanzania | NCDP/Dar es Salaam | 72 |
| **Total for Africa** | | **175** |
| 15. Brazil | EMBRAPA/Aracaju | 16 |
| 16. Jamaica | Coconut Industry Board/Kingston | 60 |
| 17. México | CICY, Yucatán | 20 |
| **Total - LAC** | | **96** |
| **GRAND TOTAL** | | **936** |

### *3.2.3. Germplasm collecting and conservation*

Through the assistance of the Asian Development Bank 8 countries in the Asia-Pacific region collected germplasm in 12 countries in areas at risk to genetic erosion and to fill the gaps in respective national collections from 1994 to 1997. A phase 2 of the project from 1998 to 2000 will involve 20 countries in collecting and conserving additional coconut germplasm. Additional collecting are also being planned for member countries in Africa and LAC regions. Collected germplasm will be conserved in respective national genebanks. To further ensure security of these genetic materials, a multi-site International Coconut Genebank (ICG) will be established in Indonesia for Southeast Asia; India for South Asia; Papua New Guinea for the South Pacific and Côte d'Ivoire for Africa. These ICG host countries will conserve the major varieties of each region, genetic materials with special traits for breeding and important materials which weak national programmes do not have the capacity to conserve. The use of molecular markers would enhance the efficiency in locating diversity during collecting activities and in characterising diversity to eliminate duplicates in the genebanks.

### *3.2.4. Germplasm evaluation, characterisation and use*

Through the assistance of the Common Fund for Commodities three countries each in Africa and in Latin America and the Caribbean will conduct multiplication trials involving six promising hybrids as common controls and four locally produced hybrids and varieties. With Asian Development Bank assistance, five countries in the Asia-Pacific region are undertaking germplasm evaluation trials to identify promising hybrids and varieties which are suitable for coconut farmers in each country. Characterisation of the national and regional genebank collections will also be undertaken to provide better data to breeders in genetic enhancement and in breeding for better varieties and hybrids. Biotechnology techniques would be useful in both the characterisation work and in breeding for special traits.

### *3.2.5. Safe germplasm movement*

A key to the development of high-yielding and well-adapted varieties is the ability of breeders to utilise a wide variety of genetic diversity. This potential has been limited in recent years by quarantine restrictions, due to the detection of organisms and related molecules which may have disease potential for threatening the coconut industry.

In order to protect the coconut industry, safe germplasm movement is imperative. However, this principle should be implemented in a progressive manner that would allow germplasm exchange with sound and adequate safeguards and promote its adoption by breeders and quarantine authorities. This would include not only health certification by quarantine officers but also the development and use of pest risk assessment protocols to provide quarantine officers with better basis for quarantine decisions on safe movement. Biotechnology techniques on indexing and pathogen characterisation would make safe movement decisions more accurate and progressive.

*3.2.6. Socio-economic and development aspects of genetic resources*

The development of varieties that promote multi-purpose uses and competitiveness of the coconut would make the coconut farmer more productive and the coconut industry sustainable. Biotechnology would improve the efficiency of locating genetic diversity and in identifying suitable genetic traits for specific products.

## 4. The role of international cooperation in the development of biotechnology

Biotechnology has the potential for enhancing the efficiency of collecting, conserving and utilising coconut genetic resources to increase the coconut farmer's productivity and to enhance the sustainability of the coconut industry. However, it requires high investment in laboratory facilities and human resources that many coconut-producing countries cannot afford. Hence international cooperation through networking among laboratories and experts in developed and developing countries is imperative. This will avoid unnecessary duplication of work, encourage complementation and synergy of activities and promote sharing of scarce resources. However, such cooperation should ensure that technologies developed by and with advanced laboratories are relevant to the needs and adapted to the conditions of developing country users. This cooperation will not only result in more efficient research activities and attainment of relevant results but would also accelerate the application of research results to benefit the coconut farmer and sustain the coconut industry.

Within the above framework, I will enumerate suggested priority areas of international cooperation in coconut biotechnology and possible participants based on ongoing activities and interests. I will do this from the perspective of the technology user as it applies to coconut germplasm conservation and use.

### *4.1. Development and application of molecular markers for locating and characterising diversity*

To enhance the efficiency of collecting and conservation, there is a need to develop appropriate molecular marker methods for locating and characterising diversity. Several laboratories have conducted research on the development and application of RFLP, RAPD, AFLP, microsatellite techniques, etc. There is a need to assess the suitability of these techniques to developing country conditions and to refine these techniques to make them cost-effective and affordable. There is also a need to rationalise what each laboratory should strategically do to promote efficient use of scarce resource. Current and potential participants are: CIRAD, Max Plank Institut (MPI), Long Ashton Research Station (RES) and Scottish Crops Research Institute (SCRI); Philippine Coconut Authority (PCA), CICY (México), Agriculture Research Institute-Mikocheni (ARIM of Tanzania), EMBRAPA (Brazil) and the four International Coconut Genebanks hosted by Indonesia, India, PNG and Côte d'Ivoire.

### *4.2. Pathogen characterisation and indexing*

Use of efficient biotechnology techniques to characterise strains of phytoplasma-caused diseases such as lethal yellowing disease, Kerala wilt, etc. and *Phytophthora* and efficient and affordable indexing techniques for these diseases and for cadang-cadang, coconut foliar decay and Tinangaja are needed. There is an urgent need to resolve whether the phytoplasma diseases are transmitted through the embryo and pollen that are envisioned as complementary methods for safe coconut germplasm movement. Current and potential participants are: CIRAD, MPI, Rothamstead Experiment Station (RES), University of Florida, CICY, ARIM and CPCRI (India) for the study on phytoplasmas; RES, IMI-CAB , MPI, PCA and RICP (Indonesia) for *Phythophthora*, and the Waite Agricultural Research Institute (WARI) for viroids.

### *4.3. Breeding for special traits*

To complement the traditional germplasm selection for breeding based on morpho-agronomic parameters, it is desirable to develop molecular marker-assisted techniques to identify genes controlling specific traits of interest. This will increase the efficiency in identifying suitable parents and reduce the gestation period for breeding improved varieties. Thus there is a need to develop this technology and to develop applications in breeding for drought tolerance, disease resistance, yield, adaptation and specific product preferences. Current and potential participants include: CIRAD, MPI, Wye College, University of Queensland, RICP, CPCRI, CRI (Sri Lanka), CICY and ARIM.

*4.4. Somatic embryogenesis*

In order to produce large numbers of planting materials of desirable varieties, the efficiency and suitability of somatic embryogenesis have to be studied. This collaborative research should aim to improve the efficiency of propagation and to assess the genetic integrity of the resulting plants. The following laboratories may be involved: CIRAD/ORSTOM, Wye College, Hanover University, University of Queensland, PCA, CICY and ARIM.

## 5. Conclusions and recommendations

Biotechnology has the potential for enhancing the efficiency of collecting, conserving and utilising coconut genetic resources to increase the coconut farmer's productivity and to enhance the sustainability of the coconut industry. However, it requires high investment in laboratory facilities and human resources that many coconut-producing countries cannot afford. Hence international cooperation through networking among laboratories and experts in developed and developing countries is imperative. This will avoid unnecessary duplication of work, encourage complementation and synergy of activities and promote sharing of scarce resources. However, such cooperation should ensure that technologies developed by and with advanced laboratories are relevant to the needs and adapted to the conditions of developing country users. This collaboration could not only result in more efficient research activities and relevant results but could also accelerate the application of research results.

Within this framework, international collaboration is recommended in the following areas of coconut biotechnology: development and application of molecular markers for locating diversity; pathogen characterisation and indexing; breeding for special traits and rapid multiplication of desirable varieties.

It is further recommended that efforts are made not only to solve issues related to biotechnology and rationalised research strategies, but also in reaching agreements that allow research laboratories to work together efficiently and effectively in the light of scarce resources. Towards this end, I propose that a coordinating committee on coconut biotechnology be created to rationalise and coordinate biotechnology work so that research could deliver relevant results that could markedly help the coconut industry in the shortest time possible.

## References


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