COMMON FUND FOR COMMODITIES

CFC TECHNICAL PAPER NO. 42

COCONUT HYBRIDS FOR SMALLHOLDERS

Project Reports and Related Papers of the Multilocation Trials to Identify Suitable Coconut Hybrids and Varieties for Africa, Latin America and the Caribbean

Pons Batugal, Dante Benigno and Jeffrey Oliver, *editors*

COMMON FUND FOR COMMODITIES

INTERNATIONAL PLANT GENETIC RESOURCES INSTITUTE/
INTERNATIONAL COCONUT GENETIC RESOURCES NETWORK

INTERGOVERNMENTAL GROUP ON OILSEEDS, OILS AND FATS -
COMMODITIES AND TRADE DIVISION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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Cover picture: Matag hybrid (Malayan Yellow Dwarf x Tagnanan Tall) in Malaysia *(photo courtesy of United Plantations Sdn Bhd)*

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FOREWORD

Coconut is grown in rainfed areas, including erosion-prone upland and hilly areas and in coastal zones where the poorest people live. Although about 12 million hectares are planted to coconut worldwide, about 96% are produced by smallholders tending less than four hectares. Coconut farmers belong to the marginalized sector of society and most live in poverty. Many of them live on land they do not own, are considered non-bankable by the formal banking sector, and most often without voice to influence government or private sector policy.

Coconut farmers face decreasing farm productivity and unstable markets for copra, the traditional dried kernel product. Their livelihood is further aggravated by ageing and senile trees, natural calamities such as drought and typhoons, incidence of pests and diseases, lack of resources to invest in innovations to improve yields and incomes and lack of availability of high-yielding and adapted varieties. To address some of these problems, the Common Fund for Commodities (CFC) supported a project of the International Plant Genetic Resources Institute (IPGRI) from 14 December 1999 to 15 December 2004 entitled "Coconut Germplasm Utilization and Conservation to Promote Sustainable Coconut Production". In this project, the performance of 30 promising coconut hybrids and varieties were tested in three African (Benin, Cote d'Ivoire, Tanzania) and three Latin American and Caribbean countries (Brazil, Jamaica and Mexico).

This publication aims to help put into practical use the results of the project by enhancing awareness of the early-bearing and high-yield potential of the newly developed coconut hybrids in increasing coconut yields and incomes of poor coconut farmers.

This publication is an invaluable contribution of CFC in co-operation with IPGRI and the FAO Intergovernmental Group on Oilseeds, Oils and Fats, in helping resource-poor coconut farmers to ameliorate their economic condition by providing them with options to improve their livelihoods. It is hoped that extension workers, researchers and policy makers would find this publication useful and relevant in improving the farm productivity of poor coconut farmers in particular and contributing to increased global coconut production in general.

Amb. Ali Mchumo
Managing Director
Common Fund for Commodities

ACKNOWLEDGEMENTS AND DISCLAIMER

The Common Fund for Commodities and the International Plant Genetic Resources Institute would like to acknowledge the collaboration and support of all the countries, institutions and personnel who contributed to the successful implementation and completion of the project, and in the preparation of this project report.

The views and conclusions presented in this report are those of the participants and do not necessarily reflect the views of the Common Fund for Commodities or of the International Plant Genetic Resources Institute.

INTRODUCTION

It is widely known that coconut farmers are poor and are becoming even poorer because of declining yields, decreasing total farm productivity and unstable international markets and fluctuating prices for copra, their main product. Coconut production and supply are thus becoming increasingly non-sustainable. This CFC Technical Report No. 42 entitled "Coconut Hybrids for Smallholders" is a timely and relevant publication as it presents various options to help poor coconut farmers around the world increase their incomes, improve overall farm productivity and make coconut production sustainable.

Farmers' income can be enhanced by increasing coconut yields. To this end, the Common Fund for Commodities funded a multilocation hybrid trials project involving three African (Benin, Côte d'Ivoire and Tanzania) and three Latin American and Caribbean (Brazil, Mexico and Brazil) countries. The project, which was implemented by the International Plant Genetic Resources Institute (IPGRI) and its International Coconut Genetic Resources Network (COGENT), tested the agronomic performance of six promising coconut hybrids produced in Côte d'Ivoire and 4-8 local hybrids produced by the six participating countries. This report includes the initial results of the trials in the six participating countries. Of the 34 hybrids tested, 16 started to fruit in only 2.5 to 3.0 years after planting compared to the 5-7 years it normally takes for the traditional Tall varieties to reach bearing age. Based on the yield projection at full bearing age of 10-12 years, these hybrids would yield up to five times more compared to the traditional farmers' varieties.

Aside from the country reports on the hybrid trials, this publication also includes other reports which were presented at the final project meeting held in Kuala Lumpur, Malaysia on 17-19 November 2004. These include the results of the hybrid development programme of the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in collaboration with partner organizations and the results of a similar programme by the United Plantation Sdn Bhd of Malaysia. Additionally, the results of coconut hybrid development in 14 countries worldwide are also presented to provide additional information on the potential benefits from growing coconut hybrids.

To achieve the high yield potential of the coconut hybrids, it is essential to effectively propagate and plant identified hybrids in suitable locations that would adequately support their full development, train farmers on improved methods of cultivation and develop strategies to enable them to source and use the recommended inputs or materials. Accordingly, this publication also includes a report on: (1) Efficient methods of producing coconut hybrid seednuts; (2) Principles and techniques to identify suitable production areas for coconut hybrids; and (3) Nursery and field management techniques to produce vigorous and early bearing palms. This material clearly shows that the introduction of coconut hybrids can only succeed and is thus only recommended where a number of specific conditions are met. This technical report also presents complementary strategies and technologies to help coconut farmers maximize their total farm productivity, including: (a) coconut-based intercropping; (b) livestock production; and (c) establishment of community-managed seedling nurseries. Moreover, village-level technologies and sample inexpensive machineries and equipment for producing high value products from all parts of the coconut are also discussed.

The report thus provides an integrated and comprehensive approach in using coconut hybrids to alleviate the plight of resource-poor coconut smallholder farmers and to encourage them to continue to produce the crop. It is hoped that this report could serve as a guide for extension workers, researchers and policy makers in undertaking various initiatives to help the smallholder coconut farmers. It is further hoped that the governments of coconut producing countries will use this report as one of their bases for developing and supporting progressive coconut production programmes that will make coconut production sustainable.

Peter Thoenes
Secretary
Intergovernmental Group on Oilseeds, Oils and Fats
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Food and Agriculture Organization of the United Nations

Chapter 1
Results of the CFC-funded multilocation hybrid trials project

- Project summary: CFC-funded multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Carribean
- Production and provision of hybrid seednuts
- Coconut hybrid trials in Côte d'Ivoire
- Coconut hybrid trials in Benin
- Coconut hybrid trials in Tanzania
- Coconut hybrid trials in Brazil
- Coconut hybrid trials in Jamaica
- Coconut hybrid trials in Mexico

Project summary: CFC-funded multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean

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Introduction

The main objectives of the multilocation trials are: 1) to assist each of the six countries to identify suitable high-yielding varieties/hybrids with high adaptation to prevailing local conditions; and 2) to estimate genotype x environment (G x E) interaction, which will serve as a guide to the application of the results to other countries with similar growing conditions.

Each of the six countries compared the six common multi-site hybrids produced and shipped from Côte d'Ivoire with 4-8 of its best hybrids/varieties. The imported hybrids are four Dwarf x Tall and two Tall x Tall hybrids which have been proven to have good yield potential in other separate trials. Each experimental unit or plot consisted of 16 palms, planted in a triangular pattern at 9m in a randomized complete block design (RCBD) with five replications. When sufficient vegetative and reproductive data will have been generated, statistical analysis shall be done at country level to compare the different genetic materials, while a combined data analysis will be conducted to determine the interaction between genotype and environment.

Project implementation

The project was approved by the CFC Executive Board on 22 October 1996 and funds were released to IPGRI in January 2000. However, the six participating countries and IPGRI pre-financed the project from 1997 to 1999 to fund preparatory activities in support of the project.

The implementation of this multilocation trial to evaluate the performance of 30 coconut hybrids and varieties and G x E interaction involved three African countries (Côte d'Ivoire, Benin and Tanzania) and three Latin American and Caribbean or LAC countries (Brazil, Jamaica and Mexico). Six promising hybrids (MYD x WAT, CRD x RIT, VTT x TAGT, MRD x VTT, MRD x TAGT and SLT x TAGT) were produced by Côte d'Ivoire and air-shipped to the five participating countries (one set was retained for the Côte d'Ivoire trial) while the six participating countries produced seednuts of their promising local hybrids/varieties to serve as controls. The 30 initial coconut hybrids/varieties that were identified to be produced and tested in the multilocation trials are shown in Table 1.

The six countries originally planned to produce four local hybrids each to be compared with the six common imported hybrids. However, this target output was exceeded because Mexico produced four additional local hybrids, namely: MYD x $MXPT_{05}$, MYD x $MXPT_{10}$, MYD x $MXPT_{11}$ and MYD x MXAT.

All six countries conducted two trials each, the first, a general performance trial using the seedlings from the first batch of hybrid seednuts sent from Côte d'Ivoire and the locally produced hybrids; and the second, using the second and third batch (only for Brazil) of seednuts from Côte d'Ivoire.

Table 1. List of multisite and local hybrid/variety trial entries

A. Six multi-site hybrids (common for all participating countries)					
Dwarf x Tall hybrids (4)				**Tall x Tall hybrids (2)**	
MYD x WAT	CRD x RIT			VTT x TAGT	
MRD x VTT	MRD x TAGT			SLT x TAGT	
B. Four locally-selected materials per country					
Côte d'Ivoire	**Bénin**	**Tanzania**	**Jamaica**	**Mexico**	**Brazil**
MYD x TKT	MYD x PNT	EAT o.p.	MYD x THT	MYD x PNT	BGD x VTT
MYD x TGT	CRD x WAT	PRD x EAT	MYD x PNT	MYD x $MXPT_{14}$	BGD x BRT
MYD x PUT	CRD xT AT	EAT x RIT	CGD x PNT	MYD x $MXPT_{09}$	MYD x BRT
PGD x VTT	PGD x VTT	EAT x VTT	CGD x THT	MYD x $MXPT_{02}$	BRT o.p.
List of variety names					
BGD	Brazilian Green Dwarf		o.p.	open pollinated	
CRD	Cameroon Red Dwarf		PYT	Polynesia Tall	
CUD	Cuban Dwarf		BRT	Brazilian Tall	
FJM	Fiji Malayan Dwarf		PNT	Panama Tall	
MRD	Malayan Red Dwarf		RIT	Rennell Island Tall	
MYD	Malayan Yellow Dwarf		SLT	Sri Lanka Tall	
PRD	Pemba Red Dwarf		TAG	Tagnanan Tall	
EAT	East African Tall		THT	Thailand Tall	
WAT	West African Tall		VTT	Vanuatu Tall	
PGD	Pumila Green Dwarf		CGD	Chowghat Green Dwarf	

Noting the potential impact of this project in increasing the yields of poor coconut farmers, the Government of Portugal funded a similar project involving the evaluation of the same six multi-site hybrid controls and four local hybrids (MYD x MZT, BGD x RLT, MZT x SGD and MZT x VTT) in Mozambique. This brought to 38 the total number of coconut hybrids being evaluated, making this project the most comprehensive coconut hybrid trial worldwide.

Major achievements

The most important result of the project is the identification of 16 early bearing and high-yielding new coconut hybrids (Table 2). The first trial showed that 16 out of the 34 coconut hybrids in the CFC-funded project started to flower and produce fruits in Brazil, Jamaica and Mexico in 2.5-3.0 years after planting compared to the seven years it would normally take the traditional varieties to reach fruiting stage. In Brazil, two hybrids from Côte d'Ivoire and two local hybrids flowered; in Jamaica, all six hybrids produced in Côte d'Ivoire flowered but none of the local hybrids; while in Mexico, only one hybrid produced in Côte d'Ivoire and eight locally produced hybrids flowered. On the other hand, flowering was not observed in the hybrids planted in Benin, Côte d'Ivoire and Tanzania during the same period. These results suggest that the drought in Africa and the generally drier conditions in that region compared to the LAC region had a negative effect on early flowering of the hybrids, suggesting a possible G x E interaction. This interaction could be verified with the vegetative and reproductive plant measurements and biotic and abiotic data to be gathered and analyzed in the next five years.

Based on the yield projection of the potential of the 16 fruiting hybrids on their fourth year, they have the potential to produce up to five tonnes of copra (dried kernel) per hectare per year at the peak of production (at 10-12 years) compared to the one metric tonne of copra generally produced by the traditional cultivars. The impact of the results from this CFC-funded project is significant as it has the potential to increase coconut yields of resource-poor smallholder coconut farmers by up to five-fold if the results are effectively promoted in many coconut growing communities and countries. Although the hybrids in the second trial are all growing well in five countries (except Benin), the potential of the hybrids could only be determined when they start to produce fruits three more years after the project termination.

Table 2. Coconut hybrids that started fruiting 2.5 - 3.0 years after planting (with check)

Hybrids produced in Cote d'Ivoire	Brazil	Mexico	Jamaica
MYD x WAT	√	√	√
MRD x VTT			√
CRD x RIT			√
MRD x TAGT	√		√
SLT x TAGT			√
VTT x TAGT			√
Locally produced hybrids			
MYD x $MXPT_{05}$		√	
MYD x MXAT		√	
MYD x $MXPT_{10}$		√	
MYD x $MXPT_{11}$		√	
MYD x $MXPT_{02}$		√	
MYD x $MXPT_{09}$		√	
MYD x $MXPT_{14}$		√	
MYD x PNT		√	
BGD x BRT	√		
BGD x VTT	√		

In Tanzania, although the few seedlings planted from the first batch of seednuts did not grow well due to drought, fire and termite infestation, the seedlings in the second replicated trial were very robust and were growing very well and are expected to flower within the next 24 months. In Côte d'Ivoire, both the seedlings in the first and second batches of seednuts are growing well. *Oryctes* beetle infestation is under control through a good integrated pest management system. In Benin, the plants from the first batch of seedlings did not do very well due to severe drought while the plants in the second batch are growing well in the three blocks (replications). The two blocks located in the low-lying area of the experimental field were waterlogged and remedies are being made to construct a drainage system.

In Jamaica, the plants in the second trial are growing well, despite some damage by the lethal yellowing disease. In Brazil, the plants in the second batch are growing well except for a few missing hills which were replanted.

The details of the individual country project results are discussed in the subsequent country project reports.

Capacity building

The second most important achievement of the project is capacity building. Based on all project components, 182 coconut researchers participated in 15 training courses and 863 attended various meetings, conferences and workshops for a total of 1045 coconut researchers worldwide whose research capacities have been enhanced (Annex 1). These events allowed coconut researchers and officers worldwide to enhance their skills on coconut genetic resources research and shared expertise, experiences and ideas to address common problems and opportunities affecting the farmers and the coconut industry. These capacity building activities have strengthened the research capability of coconut producing countries and promoted inter-country and inter-regional collaboration for conducting research to help resource-poor coconut farmers.

The results of training for the CFC-funded components of the project are shown in Table 3. The project exceeded the target outputs by 42 (number of trained researchers) based on the conducted training activities. However, because training on molecular techniques for pathogen characterization was already programmed in the newly approved CFC-funded project on lethal yellowing disease, training on (GxE) interaction analysis was substituted which was identified by the project participants as a priority activity to expand the application of project results in various environments across the world.

Table 3. Trained coconut researchers from national programmes based on target outputs of the CFC-funded components of the project

Target output of CFC-funded training components	Actual output	Excess over target output
40 coconut breeders from 30 countries trained in breeding research techniques	50 coconut breeders from 30 countries trained in breeding research techniques	+ 10 coconut breeders
30 germplasm workers from 30 countries trained in collecting and conservation	45 germplasm workers from 30 countries trained in collecting and conservation	+ 15 germplasm workers
15 biotechnologists from 10 countries trained in molecular techniques for diversity assessment	18 biotechnologists from 9 countries trained in molecular techniques for diversity assessment	+ 3 biotechnologists
30 physiologists from 15 countries trained in embryo culture techniques	42 physiologists from 15 countries trained in embryo culture techniques	+12 physiologists
10 researchers from 5 countries trained in cryopreservation techniques	12 researchers from 5 countries trained in cryopreservation techniques	+ 2 researchers
10 researchers from 5 countries trained in molecular techniques for pathogen characterization	Not done but training on Germplasm x Environment Interaction Analysis involving 9 participants was substituted	-

Nine coconut researchers from nine African countries participated in a training course on Standardized Techniques in Coconut Breeding in Cote d'Ivoire on 16-26 June 1997; and six participants from six LAC countries in Jamaica on 14-26 July 1997. A training course on collecting and conservation strategies was held in Zamboanga, Philippines on 1-12 September 1997 in which 11 participants from seven countries attended. A coconut embryo culture workshop was held on 27-31 October 1997 in Albay, Philippines, attended by 14 participants from eight countries. The first CFC-funded project workshop was held on 10-12 November 1997 in Abidjan, Côte d'Ivoire where nine participants from nine countries attended and developed the project work plans.

The 2nd International Coconut Embryo Culture workshop was held on 14-17 March 2000 in Merida, Mexico in which 28 participants from 14 countries attended. During this workshop, 14 laboratories presented the results of their two-year work. Based on the results, the participants upgraded the coconut embryo culture protocols and agreed to further test its effectiveness using their local varieties. A hands-on coconut embryo culture training course was held on 9–15 October 2000 in Albay, Philippines in which seven participants from five countries attended. The upgraded coconut embryo culture protocol was used in this training. Participants were also given research grants from the Department for International Development (DFID) funds to implement their re-entry plans upon return to duty station.

The initial results of the collaborative project with the Asian and Pacific Coconut Community (APCC) and the (now defunct) Bureau for the Development of Research on Tropical Perennial Oil Crops (BUROTROP), entitled "Evaluation of performance of high-yielding hybrids and varieties, and farmers' varietal preferences" were presented during the second project workshop of the CFC-funded multilocation trials, which was held in Dar es Salaam, Tanzania on 11-12 June 2001. During the workshop, the participants gave their observations and recommendations to improve the implementation of the project.

Two technical assistance missions were conducted by Dr Jean-Louis Konan, Côte d'Ivoire Project Leader, to monitor the status of seednuts from Côte d'Ivoire and to provide advice in project implementation to Benin (22 Mar – 2 Apr 2002) and Brazil, Jamaica and Mexico (22 - 30 July 2002). A microsatellite kit workshop was conducted in Montpellier, France on 15-24 April 2002 to train one coconut breeder and one biotechnologist each from Indonesia, India, Papua New Guinea, the Philippines, Brazil, Mexico, Côte d'Ivoire, Tanzania and Portugal (at Portugal's expense - to enable them to help Mozambique characterize its germplasm). Previously, IPGRI, in collaboration with BUROTROP, CIRAD and the European Commission, supported the development of this molecular marker technique suitable for developing countries. The workshop provided skills on the use of the technology to enable the nine countries to effectively characterize coconut germplasm. Subsequent to the training course, IPGRI had arranged for DFID to fund the nine countries to use microsatellite kits to characterize their conserved germplasm and farmers' varieties.

A project meeting was held on 25-27 July 2002 in Kingston, Jamaica as part of the project's Mid-Term Evaluation. CFC hired Dr Martin Beek of the Netherlands as Consultant to conduct a mid-term project evaluation who presented his findings at the meeting. At this meeting, the results of the country projects and other project components were reported, and information and experiences were shared. The participants (Project Leaders) discussed current project constraints and opportunities and the findings of the project mid-term evaluation and made recommendations to address them. The report on the results of the survey on "Performance evaluation of high-yielding coconut varieties/hybrids and varietal preferences of coconut farmers in different countries" has been published and disseminated.

Dr Konan Jean Louis visited Benin in June 2003 to sort out with the new Benin Project Leader (Mr Amadou Sanaoussi) the correct entries and hybrid names in the trial and to follow up the implementation of the recommendations from the project mid-term evaluation. A fourth annual project meeting was held at the Centro Cientifico Investigacion de Yucatan (CICY) in Merida, Mexico on 13-15 November 2003. A visit to the Mexican project site in Tabasco State was held on 16-17 November 2003.

Dr Jean Louis Konan, Project Leader of Côte d'Ivoire, again visited Benin in May 2004 to monitor the progress of planting of the replacement seedlings sent from Côte d'Ivoire. Dr Pons Batugal, Project Coordinator, also visited Benin in June 2004 and advised the Project Leader to improve the agronomic maintenance of the plants such as frequent irrigation during the dry season, building soil mounds around plants in the low-lying areas to prevent water logging, cover cropping, mulching and organic manuring.

CFC engaged Dr Dante Benigno of the Philippines to conduct a final project evaluation and to present his findings at the final project meeting held in Kuala Lumpur, Malaysia on 17 - 20 November 2004. The meeting reviewed the progress of the project, discussed the findings of the Consultant, the issues, recommendations and future plans. The meeting was attended by all the country Project Leaders. The GxE Interaction Analysis Training Course was held in Kuala Lumpur, Malaysia on 25 - 27 November 2004 to train the country Project Leaders on the analysis of agronomic and environmental data to evaluate G x E interaction.

At the final project meeting, the participating countries requested CFC to fund a follow up project to maximize the benefits derived from the current project and provide greater benefits to poor coconut farmers. This suggested follow up project would consist of the following components: (a) Coconut-based poverty reduction interventions using village-level technologies (transferred from Asia) to overcome poverty in coconut growing communities in Africa and LAC regions; (b) Application of G x E analysis to identify other areas suitable for coconut hybrid production; (c) Importation of the pollen and seednuts of parents of good performing hybrids to enable each country to produce planting materials (hybrids) for distribution to farmers; (d) Conservation of identified coconut lethal yellowing-resistant varieties in national genebanks and in COGENT's International Coconut Genebanks (ICG) for Africa and LAC regions and in selected farmers' fields; (e) Refining and deploying advanced multiplication technique (somatic embryogenesis) developed by Mexico to enable each country to rapidly produce planting materials; (f) Establish the ICG for Latin America and the Caribbean and strengthen the ICG for Africa and the Indian Ocean to make poverty reduction interventions sustainable; and (g) Continue capacity building to develop a critical mass of capable researchers to sustain poverty reduction interventions for resource poor coconut farmers. The submission of a follow up project was discussed with the Managing Director of CFC during the CFC Roundtable meeting for Asia in Kuala Lumpur, Malaysia in November 2004. The governments of the six participating countries also sent official requests of their respective Governments to CFC and IPGRI to support a follow up project. The recommendation for a follow-up project was supported by the results of the CFC Roundtable meetings in Burkina Faso in 2002 which identified coconut value-adding as a priority project for Africa; in Cuba in 2003 and in Malaysia in 2004 which identified poverty reduction in coconut growing communities as a priority activity for CFC to support in the LAC and Asia Pacific regions.

Annex 1. Training and capacity building activities for all project components

No.	Training and capacity building activities	Description	Venue	Dates	No. of participants
A. TRAINING COURSES					
4.	The Sub-Regional STANTECH Training Course for Africa	Training on aspects of coconut germplasm collecting, conservation and documentation, and breeding techniques	Station Cocotier Marc Delorme Abidjan, Côte d'ivoire	16-26 June 1997	9
5.	Regional STANTECH Training Course For Latin America And The Caribbean	Training on aspects of coconut germplasm collecting, conservation and documentation, and breeding techniques	Coconut Industry Board (CIB) Kingston, Jamaica	14-25 July 1997	6
6.	Coconut Germplasm Collecting and Conservation Training Course	Training on aspects of coconut germplasm collecting and conservation techniques	Philippine Coconut Authority (PCA) Zamboanga, Philippines	1-12 Sep 1997	11
11.	International Coconut Embryo Culture and Acclimatization Workshop	Assess and upgrade and standardized embryo culture technology	Albay Research Center Philippine Coconut Authority Philippines	27-31 Oct 1997	14
1.	Coconut Multilocation Hybrid/Variety Trials Workshop	Workshop to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean	Station Cocotier Marc Delorme Abidjan, Côte D'ivoire	10-12 Nov 1997	9
7.	STANTECH Training Course on Collecting and Management Of Coconut Genetic Resources	The training course focused on coconut genetic resources collecting strategy, the collecting process and the methods of descriptions of coconut varieties	Vanuatu Agricultural Research and Training Center (VARTC) Santo, Vanuatu	29 Jun – 10 Jul 1999	4
12.	Second International Coconut Embryo Culture Workshop	Assess and upgrade and standardized embryo culture technology	Centro de Investigacion Cientifica de Yucatan (CICY) Merida, Mexico	14-17 Mar 2000	28
13.	Regional Training Course On *In Vitro* Conservation and Cryopreservation On PGR	Training on Coconut Cryopreservation	NBPGR, India	12-25 Oct 2000	7
8.	STANTECH Training Course	The training course used the standardized techniques as guidelines in coconut breeding and germplasm conservation with the hope that it will help coconut researchers obtain better and comparable results	Philippine Coconut Authority-Zamboanga Research Center, San Ramon , Zamboanga City Philippines	2-7 April 2001	6

No.	Training and capacity building activities	Description	Venue	Dates	No. of participants
2.	2nd CFC-Funded Project Workshop and Initial Consultation on a Proposed Globally Coordinated Coconut Breeding	Consultations to refine the proposed globally coordinated coconut breeding programme	Mikocheni Agricultural Research Institute (MARI) Dar es Salaam, Tanzania	11-12 June 2001	39
3.	Standardized Research Techniques in Coconut Breeding	Training on coconut germplasm characterization and seednuts production (controlled and assisted pollination in seed-garden).	CNRA Marc-Delorme Côte d'Ivoire	16-28 Jan 2002	2
10.	Workshop on Coconut Genetic Resources Management Using Microsatellite Kit and Dedicated Statistical Software	Training on using Microsatellite Kit and Dedicated Statistical Software	CIRAD Montpellier, France	15-24 Apr 2002	18
14.	Coconut Cryopreservation Training Course	Training on Coconut Cryopreservation	Institut de Recherche pour le Développement (IRD) Montpellier, France	13-17 Oct 2003	5
15	Technical writing, seminar presentation, public awareness and proposal preparation	Training course on technical writing, seminar presentation, public awareness and proposal preparation	Merida, Mexico	6-7 Nov 2003	15
9.	Statistical Design and Germplasm x Environment Interaction Analysis Training Course	To acquaint training course participants with the various statistical designs and methods of data analysis that could be used for coconut research and the protocol for G x E interaction	Hotel Grand Maya, Kuala Lumpur	25-27 Nov 2004	9
Subtotal for Training					***182***
B. WORKSHOPS AND MEETINGS WITH INVITED SPEAKERS FROM ADVANCED LABORATORIES AND PRODUCER COUNTRIES					
16.	Cadang-cadang viroid-like sequences meeting	Consultation on the Cadang-cadang viroid-like sequences	Serdang, Malaysia	21-23 Apr 1997	14
17.	LAC coconut regional project proposal formulation meeting	Initial consultation to refine an LAC coconut regional project proposal	Kingston, Jamaica	7-12 July 1997	7
18.	Coconut Genetic Resources Network In Asia and the Pacific Region (CGRNAP) Phase 1/Phase 2 annual Review and Planning Meeting	Review the progress of the conservation and utilization of the coconut genetic resources project and work plans	Bogor, Indonesia	15-17 Sep 1997	28

No.	Training and capacity building activities	Description	Venue	Dates	No. of participants
19.	Annual meeting, Coconut multi-purpose uses project	Review the progress of the coconut multipurpose uses project and work plans	Bogor, Indonesia	18-20 Sep 1997	28
20.	6th COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Port Bouet, Côte d'Ivoire	13-15 Nov 1997	14
21.	ADB-Funded Projects Annual Meeting	Review the progress of the germplasm collecting and conservation project and work plans	Kuala Lumpur, Malaysia	29-31 Oct 1998	29
22.	IFAD-Funded Projects Annual Meeting	Review the progress of the coconut multipurpose uses project and work plans	Kuala Lumpur, Malaysia	2-4 Nov 1998	21
23.	International Coconut Genebank Workshop	Review the progress of the field and regional genebanks project and work plans	Madang, Papua New Guinea	6-7 Nov 1998	20
24.	7th COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Madang, PNG	9-11 Nov 1998	20
25.	IFAD-funded project meeting	Review the progress of the coconut multipurpose uses project and work plans	Ho Chi Minh city, Vietnam	13-15 Sep 1999	27
26.	ADB Phase 2 project meeting	Review the progress of the germplasm collecting and conservation project and work plans	Ho Chi Minh City Vietnam	16-17 Sep 1999	27
27.	COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Ho Chi Minh City , Vietnam	20-22 Sep 1999	16
28.	2nd International Coconut Embryo Culture Workshop	Review the progress of the project and work plans	Merida, Mexico	14-17 Mar 2000	28
29.	Meetings of ADB/IFAD Funded Coconut Research Projects and Future Directions of the Coconut Industry in the South Pacific	Review the progress of the collecting/ conservation and multipurpose uses project and work plans	Apia, Samoa	26-30 Jun 2000	20
30.	ADB & IFAD Funded Projects Joint Annual Meeting for Asia	Review the progress of the collecting/ conservation and multipurpose uses project and work plans	Manila, Philippines	10-15 July 2000	21
31.	International Coconut Genebank Workshop	Review the progress of the project and work plans	Chennai, India	17-19 July 2000	24
32.	9th COGENT Steering Committee Meeting	Review the progress of COGENT and work plans	Chennai, India	20-22 July 2000	24

No.	Training and capacity building activities	Description	Venue	Dates	No. of participants
33.	International Coconut Conference	Review the progress of the coconut genetic resources and work plans	Chennai, India	24-28 July 2000	167
34.	CFC project workshop	Review the progress of the multilocation coconut hybrid trials project and work plans	Dar es Salaam, Tanzania	11-12 Jun 2001	22
35.	10th COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Dar es Salaam, Tanzania	13-15 Jun 2001	22
36.	Poverty Reduction in Coconut Growing Communities, Project Inception and Stakeholders' Meeting	Initial consultation on a proposed project proposal	Ho Chi Minh City, Vietnam	25 Feb-1 Mar 2002	25
37.	11th COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Bangkok, Thailand	25-28 Jun 2002	20
38.	CFC Mid Term Evaluation Project Meeting	Review the mid-term progress of the CFC-funded project and work plans	Kingston, Jamaica	25-27 July 2002	15
39.	2nd International Coconut Genebank (ICG) Meeting and Consultation on Proposed Globally Coordinated Coconut Breeding	Review status of the ICGs and consultations on a proposed project proposal	Kasaragod, India	30 Oct-1 Nov 2002	31
40.	2nd Annual ADB funded Project Meeting	Review the progress of the poverty reduction in coconut growing communities project and work plans	Davao, Philippines	21-23 Aug 2003	80
41.	12th COGENT Steering Committee meeting	Review the progress of COGENT and work plans	Merida, Mexico	10-12 Nov 2003	16
42.	4th Annual CFC-funded project meeting: Coconut Germplasm Utilization and Conservation to Promote Sustainable Coconut Production	Review the progress of the CFC-funded project and work plans	Merida, Mexico	13-17 Nov 2003	21
43.	Poverty Reduction in Coconut Growing Communities (PRCGC): The Final ADB funded Project Meeting	Evaluate the progress and outputs of the project in eight Asia Pacific countries and discuss initial development impact and strategies for upscaling and replication	Ho Chi Minh City, Vietnam	27-30 Sep 2004	24

No.	Training and capacity building activities	Description	Venue	Dates	No. of participants
44.	Final CFC funded Project Meeting	Review the progress of the CFC-funded multilocation coconut hybrid trials and other project components, and discuss the findings on the final evaluation of the project and issues and recommendations	Kuala Lumpur, Malaysia	17-19 Nov 2004	26
45.	13th COGENT Steering Committee Meeting	Review the progress of ongoing and proposed projects and activities of COGENT; status of PROCORD; finalize COGENT's Strategic Plan and refine COGENT's coconut conservation strategy	Kuala Lumpur, Malaysia	22-24 Nov 2004	26
Subtotal for Workshops and Meetings					***863***
GRAND TOTAL					**1045**

Production and provision of hybrid seednuts

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Introduction

The task to produce six hybrids for the CFC-funded multilocation hybrid trials was assigned to the CNRA Marc Delorme Station in Port Bouet, Cote d'Ivoire. For this purpose, two Tall x Tall hybrids (Vanuatu Tall x Tagnanan Tall, Sri Lanka Tall x Tagnanan Tall) and four Dwarf x Tall hybrids (Malayan Yellow Dwarf x West African Tall, Cameroon Red Dwarf x Rennell Tall, Malayan Red Dwarf x Tagnanan Tall and Malayan Red Dwarf x Vanuatu Tall) were produced by Côte d'Ivoire for testing in three African (Benin, Côte d'Ivoire and Tanzania) and three Latin American and Caribbean (Brazil, Mexico and Jamaica) countries. The seednuts were harvested, stored under shade and shipped to each participating country. These hybrids were then tested and compared with at least four locally-produced hybrids in the varietal screening trial in each country. The process of producing the hybrid seednuts and providing them to participating countries are described in this article.

Materials and methods

A. Materials

Using the COGENT STANTECH Manual (Santos *et al.* 1996) as a guide, the CNRA Marc Delorme Station in Port Bouet, Côte d'Ivoire produced the six common hybrid entries for the six countries and the four local hybrids for testing in Côte d'Ivoire. Controlled pollination technique was used to produce the two Tall x Tall hybrids while the eight Dwarfs x Tall hybrids were produced using assisted pollination. The six common hybrids are:

1. Vanuatu Tall (VTT) x Tagnanan Tall (TAGT)
2. Sri Lanka Tall (SLT) x Tagnanan Tall
3. Malayan Red Dwarf (MRD) x Tagnanan Tall
4. Malayan Red Dwarf x Vanuatu Tall
5. Malayan Yellow Dwarf (MYD) x West African Tall (WAT)
6. Cameroon Red Dwarf (CRD) x Rennell Island Tall (RIT)

For Côte d'Ivoire, the four local hybrids produced for testing against the above six hybrids are:

1. Sri Lanka Green Dwarf (PGD) x Vanuatu Tall (also used by Benin)
2. Malayan Yellow Dwarf x Takome Tall (TKT)
3. Malayan Yellow Dwarf x Tenga Tall (TGT)
4. Malayan Yellow Dwarf x Palu Tall (PUT)

B. Steps in producing and distributing the hybrid seednuts

1. Selecting the parent palms

Prospective parental palms were identified based on their known characteristics from previous evaluation trials. The first criteria were the number of fruits and the percentage of meat (solid endosperm). The other criterion was the morphological traits of the palms in the field.

Based on the above criteria, the male palms were selected to produce pollen for the selected mother palms.

Figure 1. Inflorescence with mature male flowers

There were 1600 parental palms selected to produce the seednuts, as shown below:

- Tagnanan Tall	:	30 male and 100 female palms
- Sri Lanka Tall	:	30 male and 100 female palm
- Vanuatu Tall	:	30 male and 100 female palms
- West Africa Tall	:	200 male palms (also used to provide pollen to seed garden)
- Rennell Tall	:	200 male palms (also used to provide pollen to seed garden)
- Sri Lanka Green Dwarf	:	60 female palms (to produce seednuts for Benin and Côte d'Ivoire)
- Malayan Yellow Dwarf	:	350 female palms (to produce four hybrids)
- Malayan Red Dwarf	:	200 female palms to produce two hybrids
- Cameroon Red Dwarf	:	200 female palms (sufficient palms already available in the seed garden)

2. *Pollination*

The coconut is a monoecious plant which produces inflorescence more or less monthly but may be more rapid during the dry than in the wet season. Duration of the male phase is about 20 days but may vary according to variety and season. The male phase ranges for 3-5 days in Talls and about 8 days in Dwarfs. Each female flower (also called button) stays receptive for 1-3 days. Once pollination is completed, the stigma necroses and turns black.

Coconut pollen is continuously shed from inflorescence opening until the 24th day. Pollen yield per inflorescence varies from about 1 g in some Dwarfs to about 10 g in Talls. Naturally shed pollen is no longer viable after six days and viability is easily affected by alternating wet and dry regimes and low night and high day temperatures.

Controlled pollination

Most Tall and some Dwarf coconut varieties have overlaps in the emissions of their male and female flowers. Hence for these varieties, it is important to use the controlled pollination technique to prevent selfing (See Annex 1 for illustrations of controlled pollination). Under this technique, the inflorescence is bagged before it opens and the male flowers are removed as the spathe opens. When the stigmas of the female flowers are receptive, they are pollinated with the desired pollen. This controlled pollination technique was used to produce the hybrids VTT x TAGT, SLT x TAGT, PGD x VTT, MYD x TKT, MYD x TGT, MYD x PUT and some seednuts of the two hybrids MRD x TAGT, MRD x VTT

In collecting the pollen, the inflorescences of the male palms were bagged just before or upon the opening of the spathe. The spikelets bearing mature male flowers are removed and sent immediately to the laboratory.

At the laboratory, the male flowers were crushed and dried at 40°C for 20 hours. The dried male flowers were then sifted to clean the pollen from debris. The pollen obtained was conditioned and packed in sterilized ampoule and kept to the freezer at -20°C (Rognon and de Nuce 1973) up to the utilization period.

For the Tall variety (TAGT), inflorescences were emasculated upon the opening of the spathe and bagged 72 hours after. For the Dwarf varieties (MRD, MYD, PGD), inflorescences were emasculated and bagged 48 hours before the opening of the inflorescences.

The pollens (0. 25 g) were mixed with talc (4. 75 g) at the laboratory in isolated condition. The pollination is done according to the crossing plan. The pollen of selected tree of the genitor (male palm) is used to pollinate selected tree of the female palm. The box which contains the pollen is marked (number of genitor, number of the palm). The technician distributes the pollen every morning to the pollinators at the laboratory. They have to verify that the number of the pollen (written on the box) is corresponded to what is planned in the crossing plan for each female palm. The pollen was applied to female flowers when they became receptive (button tip becomes wet). Pollination was then applied once for the Tall varieties and three times for the Dwarf varieties. The methodology applied was the same as described by Wuidart and Rognon (1978) and Nuce *et al* (1973). The bags were collected 10 days after the last pollination. The spadix of fruit bunches used in crosses were marked with paint to avoid any error.

Assisted pollination

This technique was used to produce the hybrids MYD x WAT, CRD x RIT and some seednuts for MRD x TAGT and MRD x VTT (See Annex 2 for illustrations of assisted pollination).

The mother palms of these hybrids are isolated and buffered by oil palm plantations and located on three different plots (each for MYD; CRD and MRD). The three seed gardens were at least one kilometre apart.

The pollens of TAGT and VTT produced for controlled pollination were also used for assisted pollination on MRD female palms. In producing pollen of WAT and RIT for use in assisted pollination, the inflorescences were not bagged. Upon the opening of the spathe, the spikelets were removed and sent immediately to the laboratory. The male flowers were crushed and dried in the special room (30°C temperature; 45-50% relative humidity). After 24 hours, the dried flowers were sifted to collect the pollen. To reduce the moisture, the pollen was further dried and kept in a freezer at -20°C. Contrary to the controlled pollination, the male flowers collected on many palms on the each variety are mixed. So the pollen obtained is from many palms of each selected male variety. The pollens were produced at Marc Delorme Station is packed in the plastic bag (marked by the name of the variety) and sent regularly to the seed gardens which are located about 100 km from the station.

For the mother palms (MYD, MRD, CRD), the emasculated inflorescences were pollinated everyday (pollen mixed with talc) during the receptive phase of female flowers. For each receptive inflorescence, pollination was done 10-12 times. The mixture of 5 parts talc 100 parts pollen was prepared at the field before each pollination (Nuce and Rognon 1973 and 1975). Each mixture (105 g) is used to pollinate 100 inflorescences of many palms of female variety.

For both of the two pollination techniques, the following activities were controlled to avoid any error and to ensure high efficiency:

- Testing pollen viability (see STANTECH Manual)
- Close supervision of technicians
- Timely and thorough emasculation
- Evaluation of the percentage of fruit set three months after pollination

3. Harvesting seednuts

When the seednut is mature it becomes brown. This status appears from 11 to 13 months after the pollination of the female flower. However, before that period, from 7 to 8 months after pollination, the seednut are marked. The number of the pollination is written on the nuts. All the nuts collected per pollination and per inflorescence are grouped together to avoid the mixing of the seednuts of several hybrids in the same field. After 11 months and based to the date of the pollination which is written on the inflorescences, the seednuts are harvested every month.

In assisted pollination, the seednuts are also harvested at the same age. They are harvested once a month on dwarf female palms.

With the two techniques, the seednuts are grouped per plot and per hybrid, before their transfer to storage area. A total of 19 515 seednuts were harvested for the mutilocation trials. The first batch consisting of 7324 seednuts was harvested from 1999 to 2000. The second batch of 12 191 seednuts was produced in 2001 to 2003.

4. Making arrangements with importing countries

Each participating country was requested to prepare for receiving the seednuts in collaboration with Marc DELORME Station to ensure that they receive the seednuts on time and in good order.

The each participating country was requested to do the following.

- Secure and send an import permit to Marc DELORME three months before sending the shipment
- Obtain from local quarantine office the quarantine requirements to be followed at shipment point and at port of entry. Also post entry quarantine facilities were requested and both information were sent to Marc Delorme..

- Make appropriate arrangement with customs office at port of entry for tax and duty exemption.

Upon receipt of the above information, Marc DELORME followed the requirements at shipment point. Based on the above, the total 19 515 seednuts were shipped to the participating countries.

5. Management of seednuts before shipment

After the harvesting the seednuts, they are carried to the storage area. The seednuts are packed together per hybrid. At the storage area, the good seednuts to be shipped are selected using the criteria below:

a) The small seednuts (weight under the mean of the nut weight of the hybrid), the germinated seednuts, the immature seednuts, abnormal seednuts (bad size) and the seednuts without water inside are eliminated.
b) The selected good seednuts are cleaned and treated with fungicides and pesticides based on the phytosanitary requirements of each country.
c) 24 hours after the treatment, the seednuts are packed in synthetics bags for shipping.

Despite the good care of the seednuts, the shipments to the five participating countries were delayed due to the delayed release of funds. As a result, most of them were dried resulting in low recovery of high quality seedlings. The project produced a second batch of seednuts and sent to the countries after one year.

Due to previous arrangements with customs and quarantine at the port of entry, the hybrid seednuts from Côte d'Ivoire were received and released efficiently in all countries except in Brazil. For lack of suitable quarantine arrangements, the delay in the release of the second batch of seednuts to the trial site in Aracaju/Itaporanga, Brazil also resulted in low seedling recovery. A third batch of seeednuts from Marc DELORME Research Station was therefore sent to Brazil.

The general plan for producing, treatment, providing hybrid seednuts to the participating countries is shown in Table 1.

Table 1. Schedule of production and distribution of seednuts to participating countries for the multilocation trials project (first and seconds batch)

Participating Country	Pollination	Harvesting (of seednuts	Seednut quarantine treatment (if needed) and air shipment from Côte d'Ivoire	Quarantine and customs clearance at receiving country	Nursery sowing	Field transfer of seedlings
1. Benin	1998 to Sept. 2000	Jun 2000; July 2001	May 2000; Oct 2001	Jun 2000; Oct 2001	Jun 2000;Oct. 2001	Jun 2001;May 2002
2. Côte d'Ivoire	1998 to Sept. 2000	1999; July 2001	1988- 2003	1998-2003	1998-2003	May 2000; May 2002
3. Tanzania	1998 to Sept. 2000	Jan. 1999; Jan 2002.	Jan. 1999; Jan 2002	Feb 1999; March 2002	Feb 1999; March 2002	Nov 1999; Nov. 2002
4. Jamaica	1998 to Sept. 2000	Jan. 1999 ; Jan 2002	Feb 1999; Feb 2002	Feb 1999; March 2002	Feb 1999; March 2002	Oct 1999; Oct. 2002
5. Brazil	1998 to Sept. 2000	Jan. 1999 Jan. 2002	Feb 199; Aug 2002	Feb 1999; Sept 2002	March 1999; Sept 2002	Aug 1999; Aug. 2002
6. Mexico	1998 to Sept. 2000	Jan 1999 Feb 2002	Feb 1999; Jan 2002	Feb 1999; Feb. 2002	Feb 1999; Jan. 2002	Aug 1999; Aug. 2002

More than 7324 seednuts were produced to supply the participating countries in the first batch. Due to the delayed release of funds, the germination obtained in the countries was low. Thus the second batch (12191 seednuts) was produced and sent to the countries a year later. The excess seednuts enabled Marc Delorme Station to provide the third batch to Brazil and additional seedlings to replant dead seedlings in Benin.

6. Monitoring of seednut condition and resulting seedlings

After the shipment of the seednuts to the countries, the Marc DELORME research project leader was requested to visit and monitor the project implementation in four countries during 2002.

- In Benin, the country project leader was trained on how to recognize legitimate seedling. The first batch was planted in the station where the soil is poor. The plants were seriously affected by a serious drought during the dry season. Advices were given to ensure success of the second batch of plantings. Despite of that, the trial was not efficiently watered. Marc DELORME had to provide additional seedlings for replacement.
- In Mexico, the first batch was planted in two farmer sites. The seedlings appeared to be growing well. There were enough seedlings to plant the second batch. We proposed an appropriate design, due to the heterogenous nature of the planting site. The second trial was also located in farmer area. The three sites are based in the region affected by lethal yellowing disease. So, the hybrids will be tested against this disease.
- In Brazil, the quarantine service (Brazilia) is very far from Aracaju/Itaporanga where the trial was supposed to be the planted. The second batch stayed too long at quarantine (more than 60 days), also resulting in low germination rate. Marc DELORME sent the third batch of seednuts and these together with some seedlings recovered from the second batch were used to conduct a full trial in Itaporanga which site is adjacent to the COGENT International Coconut Genebank for the LAC region.
- In Jamaica, the trial (first batch) is planted in farmer field. Enough seedlings were obtained in Kingston to plant the second trial. As the country is also affected by the lethal yellowing disease, the hybrids will be tested against it.

Results and discussion

The 5 686 inflorescences extracted from 550 male palms were treated to produce 41 160 g of pollen (Table 2). About 7g of pollen were obtained per inflorescence which confirmed the result presented by Nuce and Rognon in 1972. The quality of the pollen was very good, because its viability (average of 40.9%) was superior to the .accepted international .standard of 25% (STANTECH manual). The same rate was obtained by Wuidard and Rognon in 1978 at Marc Delorme Station when they produced pollen for seed garden.

Table 2. Pollen produced for assisted and controlled pollinations

Variety	Number of inflorescence treated	Quantity of pollen obtained (g)	Quantity of pollen utilized (g)	Mean of Pollen viability (%)
TAGT	879	7035	6560	42.1
VTT	1825	14600	13500	40.7
WAT	820	6560	6570	39.8
RIT	524	3140	3140	39.7
TKT	501	3005	2995	40.2
TGT	549	3295	3195	41.2
PUT	588	3525	3420	42.3
Total/Mean	**5 686**	**41 160**	**39 380**	**40.9**

The pollens produced were used to pollinate 850 mother palms. The 25 619 controlled and assisted pollinations were carried out (Table 3) which allowed Marc Delorme to harvest 20 770 seednuts (Table 4). The high number of successful controlled pollinations was realized with the hybrid SLT x TAGT but the maximum number of harvested seednuts was derived from the hybrid VTT x TAGT. With regard to assisted pollination, the maximum number of successful pollination was observed from CRD x RIT where the highest quantity of seednuts was also collected.

Instead of the 150 seednuts initially planned, more than 180 seednuts per hybrid were shipped to each participating country to increase replacement allowance for damaged or abnormal seedlings.

Table 3. Summary of successful pollinations

Type of pollination method	Types of hybrid	Number of pollination planned	Number of pollination realized
Controlled Pollination	VTT x TAGT	1200	1267
	SLT x TAGT	1300	1736
	MRD x VTT	500	661
	MRD x TAGT	500	572
	MYD x TKT	200	301
	MYD x TGT	200	300
	MYD x PUT	200	243
	PGD x VTT	400	1098
Sub-total		**4 500**	**6 178**
Assisted Pollination	MYD x WAT	2400	6300
	CRD x RIT	2400	6901
	MRD x TAGT	2400	3440
	MRD x VTT	2400	2800
Sub-total		**9 600**	**19 441**
Grand total		**14 100**	**25 619**

Table 4. Number of the seednuts produced and shipped

Type of hybrid		Quantity of expected seednuts	Quantity of seednuts harvested	Quantity of seednuts shipped	Quantity of seed nuts left in Cote d'Ivoire
Common Hybrids	VTT x TAGT	2436	2453	1521	932
	SLT x TAGT	2479	1604	1228	376
	MRD x VTT	925	1455	1210	245
	MRD x TAGT	1002	1395	1210	185
	MYD x WAT	5200	5300	1800	3500
	CRD x RIT	**5211**	**5311**	1840	3471
Sub-total 1		***17 253***	***17 518***	***8809***	***8709***
Local Hybrids	PGD x VTT	988	1516	260 (for Benin)	1256
	MYD x TKT	757	562	-	562
	MYD x TGT	780	657	-	657
	MYD x PUT	802	517	-	517
Sub-total 2		***3 327***	***3 252***	***260***	***2 992***
First batch		**15 304**	**7 324**	**5550**	**1774**
GRAND TOTAL		**20 580**	**24 848**	**14 619**	**14869**

** The total of the seednuts produced is 24 848. After screening in storage area, 19 515 good seednuts were retained for the trials in the six participating countries.*

Lessons learned and recommendations

This project is an opportunity for the six countries to work together and meet regularly. To improve efficiency of project implementation in the next project the arrangements below are recommended.

1. Before the beginning of field activities, the project coordinator has to visit the participating countries to confirm that:
   - Appropriate sites are selected for the activities
   - Administrative organization is efficient to release in a timely manner funds for project activities.
2. Allocate adequate budget to address every problem met during project implementation
3. It is possible through one project involving many countries to achieve several objectives. In this case, some countries select high producer hybrids, some others test the level of producing and the resistance against disease.

Conclusion

The target activities of seednuts production at Marc Delorme Station /Côte d'Ivoire were very well implemented. Sufficient seednuts were harvested and shipped to participating countries.

Even after the shipments, more than half of the harvested seednuts were reserved in Côte d'Ivoire for other purposes. Some were supplied to countries as second and third shipments to Brazil and Benin which had difficulties in establishing the trials.

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Annex 1. Illustrations of controlled pollination

Figure 1. An open inflorescence

Figure 2. Bagging the inflorescence

Figure 3. Collecting spikelets

Figure 4. Collecting male flowers

Figure 5. Crushing male flowers

Figure 6. Drying male flowers

Figure 7. Collecting pollen

Figure 8. Testing the viability of pollen

Figure 9. Mixing pollen with talc under isolated condition in the laboratory

Figure 10. Pollinating receptive female flowers

Figure 11. Checking the pollination bag

Figure 12. Marked seednuts harvested 12 months after pollination

Annex 2. Illustrations of assisted pollination

Figure 1. Mature inflorescence

Figure 2. Cutting spikelets and collecting male flowers

Figure 3. Crushing male flowers

Figure 4. Drying male flowers

Figure 5. Extracting the pollen

Figure 6. Conditioning the pollen

Figure 7. Pollen kept in freezer at -20° C

Figure 8. Emasculating the inflorescence

Figure 9. An emasculated inflorescence

Figure 10. Mixing pollen and talc in the seed garden

Figure 11. A female palm (MYD) pollinated with WAT

Figure 12. Hybrid (MYD x WAT) seednuts on mother palm

Coconut hybrid trials in Côte d'Ivoire

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Introduction

Coconut in Côte d'Ivoire covers roughly 40 000 ha, more than 60% of which are located in the country's coastal region (Zakra *et al.* 1995). Almost half of the country's total coconut area (19 500 ha) is tended by about 12 500 poor coconut farmers who cannot afford to properly maintain their fields, which substantially contributes to low productivity. Additionally, most of these plantations are more than 25 years old and planted with low-yielding, old and senile local varieties. Though hybrids have been introduced in Côte d'Ivoire, they are mostly planted in agro-industrial estates.

Annual total copra production amounts to 64 000 tonnes, most of which are sold to and processed into oil by industrial factories based locally and in Ghana. On the other hand, in Côte d'Ivoire's southeast region, coconuts are mainly sold as fresh nut for drinking (Asset *et al.* 2004).

Rationale and justification of the project

Since 1962, the Marc Delorme Research Station had introduced into the country some 53 accessions representing the entire inter-tropical zone (Africa, Asia, Latin America, the Caribbean and the Pacific) for conservation and as research materials, primarily in the development of hybrids. These varieties were tested through several trials using reciprocal recurrent scheme (Bourdeix 1989). The MAWA or West African Tall x Malayan Yellow Dwarf (WAT x MYD) hybrid, which was developed by CIRAD, is well adapted and have been promoted all over the world. The Tagnanan Tall (TAGT), which originates from Davao, Philippines, was introduced in 1974 (Gemperle and Fremond 1979) and provides 1.5 t ha^{-1} $year^{-1}$ of copra. The Tagnanan Tall x Malayan Red Dwarf (TAGT x MRD) hybrid in Marc Delorme produces more than 5 t ha^{-1} yr^{-1} of copra. A Dwarf variety called Pumila Green Dwarf (PGD) appears to be tolerant to lethal yellowing disease (LYD) in Ghana (Konan and Allou 2002). MRD crossed with Indonesia Tall produces a high-yielding hybrid with big nuts. Hybrid PB 113, or Cameroon Red Dwarf crossed with Rennell Island Tall (CRD x RIT), is capable of producing 5.5 t ha^{-1} $year^{-1}$ of copra.

To further study the suitability and efficiency of these varieties and hybrids under Côte d'Ivoire farm conditions, the country participated in an international project of IPGRI/COGENT funded by the Common Fund for Commodities (CFC) entitled "Coconut Germplasm Utilization and Conservation to Promote Sustainable Coconut Production". A component of the project is the "Multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean." The project, which ran from 1999-2004, was participated in by five others countries namely Benin, Tanzania, Brazil, Mexico and Jamaica. During the project, six commons hybrids produced by Côte d'Ivoire (MYD x WAT, CRD x RIT, VTT x TAGT, MRD x VTT, MRD x TAGT and SLT x TAGT) were tested by each participating country in addition to their own four local hybrids. The behavior and characteristics of these hybrids were monitored, evaluated and analyzed with regards to different soil and climatic conditions.

Research methodology

Hybrids production

All the hybrids used in the trials were produced through both controlled and assisted pollinations. In controlled pollination, inflorescences are bagged before the spikelets are collected. In the laboratory, the male flowers are stripped off and lightly crushed to promote drying. The pollen obtained are conserved in a freezer and used to pollinate female inflorescence which are bagged and emasculated. The hybrids produced using this technique include SLT x TAGT, VTT x TAGT, PGD x VTT, MYD x TKT, MYD x TAGT, MRD x VTT, MRD x TAGT and MYD x PUT.

On the other hand, in assisted pollination, inflorescences are not bagged before the spikelets are collected. In the laboratory, the male flowers are stripped off and lightly crushed to promote drying. The extracted pollen is then mixed with talc and used to pollinate the female flowers, which are isolated in the field.

The seed garden where pollens were collected which contains the female palms (CRD, MRD and MYD) is located in an isolated oil palm plantation about 100 km from the Marc Delorme Station. This method was used to produce the hybrids MYD x WAT, CRD x RIT, MRD x TAGT and MRD x VTT.

Brief characteristics of the parent varieties

The following are the characteristics of the parent varieties used in producing the hybrids under Côte d'Ivoire conditions:

- The MYD, a variety that originated from Malaysia, is autogamous (95%) and weighs between 600 to 800g (mature fruit). Each palm produces 80 to 100 nuts per year without irrigation. In this project, the MYD was used as control to evaluate the other dwarf varieties under study.
- The MRD, also from Malaysia, has the same precocity and density as the MYD. About 70 to 100 nuts could be harvested per palm annually, with each fruit weighing between 740 and 1080 g.
- The CRD, which comes from Kribi in Cameroon, produces 80 to 100 nuts per palm per year, whereby each nut weights around 800 g. When this variety is crossed with RIT and WAT, the average fruit weight can reach up to 1200 g and 1710 g, respectively (Bourdeix *et al.* 2000).
- The TAGT came from the Philippines and produced up to 94 nuts per palm per hectare per year and has tolerance to nut fall and bud rot caused by Phytophtora.
- The VTT was introduced in the 1960s from the Pacific. This variety produces about 100 nuts per palm after three years of planting and is tolerant to LYD in Ghana. The hybrid produced from crossing VTT with PGD (Pumila Green Dwarf) are used to rehabilitate plantations in Côte d'Ivoire.
- The Sri Lanka Tall (SLT) variety was introduced in 1971 and is known to be highly susceptible to lethal yellowing disease (LYD). This variety begins flowering after the sixth year of planting and each nut can weigh up to 1348 g.
- Three Tall populations (TKT, TAGT, and PUT) from Indonesia were received in 1984 and were also used in the trials. These populations usually flower after the sixth year of planting.

The detailed description and pictures of the parent materials are presented in Annex 1.

Results and discussion

Soil and leaf analysis

Two hybrids trials were conducted at Marc Delorme Research Station located in the south region of Côte d'Ivoire and some 12 km from the coast (latitude 03°5 N and longitude 05°16 E). To determine the characteristics of the soil, samples were collected from four depth levels (30 cm, 60 cm, 90 cm and 120 cm) in five different sites (replications 1 to 5) of the trial.

The results of the soils analysis (Table 1) show that the cation exchange capacity (CEC) is variable from 3.3 to 4.4 me per 100 g, which is considered very low. This was mainly attributed to the sandy nature of the soil. Therefore, mineral fertilizers were applied twice a year (in April and September) to augment soil nutrients. The average C/N content is 9.4% while the soil pH is moderately acidic, which are suitable for growing coconut. Organic matters from coconut husk were also used in the trials to accelerate the development of the seedlings.

Table 1. Soil characteristics of the trial sites

Level (cm)	Organic Matter (%)			Azotes	P (ppm)		CEC (me/ 100g)	$Ca2^+$	(me/100 g)		
	PH	C/N	Carbon		Total	Assm			Mg2	K^+	Na^+
Rep 1 30	5.3	11.0	0.53	0.050	283	42	4.25	0.06	0.07	0.05	0.08
Rep 1 60	5.1	12.5	0.44	0.035	256	170	4.42	0.05	0.07	0.06	0.06
Rep 1 90	5.3	6.3	0.29	0.046	232	171	3.31	0.10	0.05	0.07	0.05
Rep 1 120	5.4	7.9	0.35	0.045	299	71	3.67	0.80	0.03	0.05	0.05
Mean	**5.3**	**9.4**	**0.40**	**0.044**	**298**	**114**	**3.91**	**0.25**	**0.06**	**0.06**	**0.06**

From the results of the leaf analysis as shown in Table 2, it appears that the seedlings were deficient in N, P, K, Ca and Mg. Based on the soil and leaf analyses, fertilizer application rates were computed and recommended for each trial site. Table 3 summarizes the type and quantity of mineral fertilizers, applied twice a year, in each site.

Table 2. Result of the leaf analysis conducted in 2004

Hybrids	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
MYD X WAT	0.847	0.084	1.166	0.257	0275
CRD X RIT	0.731	0.078	1.494	0.180	0.209
VTT X TAGT	0.848	0.074	1.301	0.227	0.151
SLT X TAGT	1.069	0.079	1.691	0.202	0.089
MRD X VTT	1.003	0.088	1.783	0.229	0.126
MRDX TAGT	1.483	0.135	1.314	0.345	0.222
MYD X TKT	2.123	0.150	0.803	0.365	0.118
MYD X TGT	2.002	0.143	1.024	0.227	0.067
MYD X PUT	2.134	0.146	1.019	0.232	0.070
PGD X VTT	2.249	0.097	0.841	0.233	0.077
Mean	**1.449**	**0.107**	**1.244**	**0.250**	**0.140**

Table 3. Fertilizers applied for the two trials

Field number	Type of fertilizer and quantity per palm (g)	Equivalent in mineral per palm (g)	Total quantity applied (g)
PBGC 45-1	Urea (46% N) = 500	N = 230	312 500
Year planted: 2000 No. of palms treated: 625	-Phosphate three calcium (P_2O_5, 34%) = 250	$P_2\ 0_5$ = 85	156 250
	Chlorure de Potasse (K_20, 34 %) = 200 g	K_20 = 1200	125 000
	Kieserite (Mg0, 27 %) = 1000	Mg0 = 270	625 000
Subtotal for PBGC 45-1	*1950*	*1785*	*1218 750*
PBGC 45-2	Urea (46%N) = 300	N = 138	324 000
Year planted: 2002 No. of palms treated: 1080	Phosphate three calcium ($P_2\ 0_5$, 34%) = 200	$P_2\ 0_5$ = 68	216 000
	Chlorure de Potasse (K_20, 34%) = 800	K_20 = 480	864 000
	Kieserite (Mg0, 27 %) = 400	Mg0 = 108	432 000
Subtotal for PBGC 45-2	*1700*	*784*	*1 836 000*
GRAND TOTAL	**3650**	**2569**	**305 475 000**

Climatic data

Côte d'Ivoire's climate is divided into two dry seasons (December-April and August-September) and two wet seasons (May-July and October-November) (Konan KJL 1997).

A meteorology station is located between the two trial sites in Marc Delorme. Climatic data is collected three times daily in the early morning (0600H), mid-day and in the early evening (1800H). During the last 20 years (1984-2004), the recorded average rainfall level per year varied between 1166 mm to 2238 mm while the mean number of days with rain was more than 100 annually and the cumulative water deficit was less than 1000 mm per year. The mean temperature stood at 26.2°C and the relative humidity was at 86.9% for 2196 hours/year of sunshine.

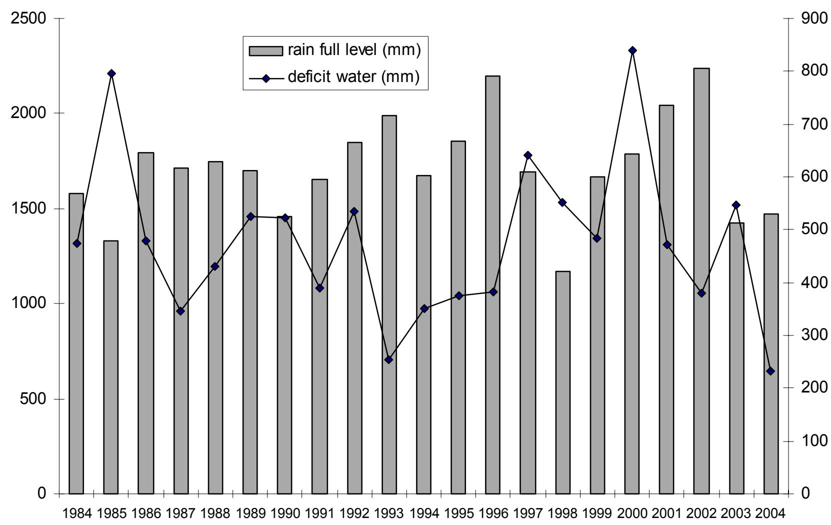

Figure 1. Graphical representation of 20-year rainfall data (1984 to 2004) in Côte d'Ivoire

Initial vegetative data

To produce the six common hybrids for the six participating countries, Marc Delorme selected good performing palms in their seed gardens to serve as male and female parents for the production of Dwarf x Tall hybrids. Six promising hybrids were produced by Côte d'Ivoire for the six countries participating in the multilocation trials, namely: MYD x WAT, CRD x RIT, MRD x VTT, MRD x TAGT, VTT x TAGT and SLT x TAGT. The four local hybrids (MYD x TKT, MYD x TGT, MYD x PUT and PGD x VTT) used for comparison in the first trial batch were also produced by the Marc Delorme Station and planted at the station in October 2000 on a five-hectare block using randomized complete block design(RCBD) with three replications. Each replication contained 10 hybrids (10 entries) with 16 palms. The palms were planted at a density of 143 palms/ha in a triangular pattern at a distance of 9 m. These seedlings were maintained by four technicians who carried out regular weeding and fertilization. The local hybrid PB 121 was also planted to replace plants that died as well as to avoid border effects. Initial vegetative data indicated that the Tall x Tall (VTT x TAGT; SLT x TAGT) and MYD x WAT hybrids grew faster than the other hybrids under study.

Due to the low germination rates in the first batch of seednuts, Côte d'Ivoire was requested to produce another set of 200 seednuts per hybrid for the second batch of hybrid seednuts to supply the needs of the six participating countries for their respective second country trials.

During 2001-2002, a total of 8759 hybrid seednuts (second batch) of the six common hybrids were produced and shipped to the other participating countries. The second batch of seednuts was treated with *Azodrin* or *Monocrotophos* to prevent pest infestation. In June 2002, the second batch of seedlings for Côte d'Ivoire was sown in the nursery, later transplanted in polybags and planted on the field. The seedlings in the two trials were maintained following recommended cultural management practices.

Vegetative data (i.e., number of leaves produced, base girth and plant height) were collected every three months. Table 4 shows that the hybrid SLT x TAGT grew the tallest during the trials, while the CRD x RIT hybrid grew the least and also had the smallest base girth. In general, the hybrid plants showed better growth which is indicative of hybrid vigor.

Table 4. Vegetative data on the trial PBGC45-1 (first batch in October 2000) and PBGC45-2 (second batch in June 2002)

Type of hybrid	Number of leaves produced per year		Girth of plant base as of December 2004 (cm)		Height of plant as of December 2004 (cm)	
	PBGC45-1 (1st Batch, Oct 2000)	PBGC45-2 (2nd Batch, June 2002)	PBGC45-1 (1st Batch, Oct 2000)	PBGC45-2 (2nd Batch, June 2002)	PBGC45-1 (1st Batch, Oct 2000)	PBGC45-2 (2nd Batch, June 2002)
A. Multilocation (common) hybrids						
VTT x TAGT	12	12	39	52	290	352
SLT x TAG	12	12	46	56	331	381
MRD x WAT	13	14	46	68	293	380
CRD x RIT	12	12	31	43	208	275
MRD x VTT	13	13	47	51	323	333
MRD x TAGT	13	13	47	49	314	319
B. Local hybrids						
MYD x TKT	12	12	33	46	235	311
MYD x TGT	13	13	46	51	300	337
MYD x PUT	12	12	35	52	252	337
PGD x VTT	12	13	34	55	235	334
Mean	**12**	**13**	**40.4**	**52.3**	**278.1**	**336**

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Annex 1. Description and pictures of the parent varieties of the hybrids produced in Côte d'Ivoire for the multilocation trials

Malayan Yellow Dwarf (MYD)[1]

Aside from using it to produce one common hybrid for the trial, MYD was also used to produce local hybrids in Côte d'Ivoire, Benin, Jamaica, Mexico and Brazil. MYD was first introduced in Benin from Marc Delorme Research Station of Côte d'Ivoire in 1960. It is planted in seed gardens and used to produce MAWA hybrid or PB 121 (MYD x WAT) by assisted pollination. MYD is also commonly used in the country as ornamental palm in home gardens.

History and description

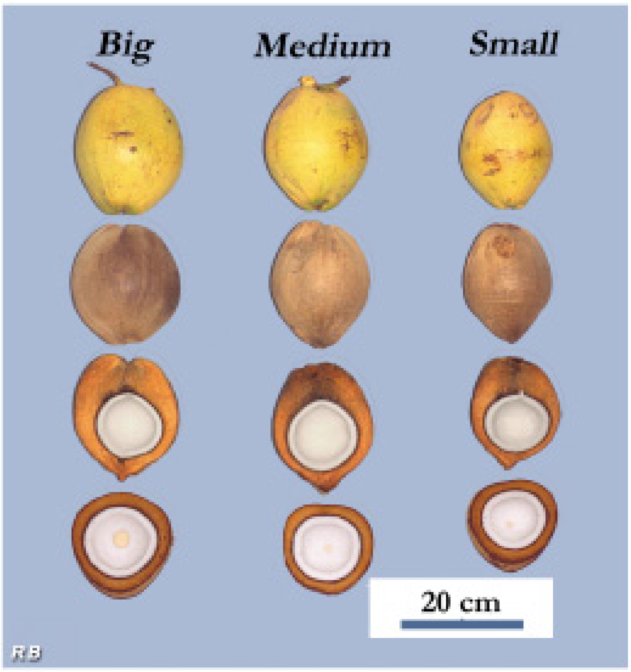
The MYD introduced in the country from the Marc Delorme Station was originally called the Ghana Yellow Dwarf of Malaysian type. The variety's Malaysian origin has not been proven, but it is extremely likely in view of its resemblance to MYD and given the fact that the two countries have had trading relationship during the colonial period. Generally, the Dwarf types do not have a bulb at the base of the stem, but under good environmental conditions Dwarfs could have a slight swelling at the base of the stem. The MYD is classified in that group. The MYD has a fast growth rate and does grow taller compared to other Dwarfs. Dwarf types differ in the colour of their sprouts, leaf stalks, inflorescences and fruits. For the MYD, these are all pale yellow. The MYD is a direct autogamy type; it has a lengthy female phase with a complete overlapping of male and female phases, with the female phase starting just before the spathe opens.

Growth and production

Dwarfs are generally precocious but this character is affected by ecological conditions. Under Marc Delorme Station conditions, MYD flowers 34 months after planting and fruits could be harvested within 55 months. It produces an average of 32 female flowers per inflorescence. In good cultivation conditions, the MYD can produce from 16 to 18 bunches and about 125 nuts per palm per year. The MYD has a better nut composition (i.e., ratio = albumen/fruit = 0.49) on average, although it produces not much of copra and oil (83 g/nut).

[1] From Nuce de Lamothe, M. de and F. Rognon. 1977. Les cocotiers nains à Port Bouët (Côte d'Ivoire). I. Nain Jaune Ghana, Nain Rouge Malaisie, Nain Vert Guinée Equatoriale et Nain Rouge Cameroun. Oléagineux, 32.

Malayan Yellow Dwarf (MYD)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Malayan Red Dwarf (MRD)

By R. Bourdeix, A. Othman, and J.L Konan

History and description

It is supposed that the Dwarf palms of Malaysia – in red, green and yellow forms- were introduced from Indonesia between 1890 - 1900. The colour of the seedling sprouts, the leaf stalks, the inflorescence and the immature fruit is not really red but more like bright orange.

The palm generally has a thin stem, about 22 to 25 cm in diameter, with no bole. When growing conditions are good, it may have a small bole (35 to 40 cm in diameter).

The youngest leaves at the top of the palm are quite soft. Its upper canopy resembles dishevelled hair, compared, for example, with the Cameroon Red Dwarf (CRD), which has a straight and erect canopy.

Because of its short peduncle, the bunch is well supported by the leaf petioles. The reproduction system has been described as direct autogamy. MRD characterization data can be found in at least seven countries: Brazil, Côte d'Ivoire, Fiji, India, Philippines, Tanzania, and Vanuatu.

Identification

More than 30 types of Red Dwarfs are referenced worldwide. Some of them look very similar to the Malayan type: Red Dwarfs from Sri Lanka, from Chowgat in India, from Nias in Indonesia, from Chumpon in Thailand, and even from Cuba. Molecular analysis techniques will help to determine if these Red Dwarfs are identical or not.

Other Red Dwarfs can be easily distinguished from the Malayan type. CRD bears pear-shaped fruits with paler orange colour. Some Red Dwarfs from the Pacific region produce bunches with long peduncle and numerous smaller fruits having a more intense red-orange colour (such as the Tahiti Red Dwarf). Fruits of some other Red Dwarfs from Papua New Guinea have a tit or lug at the bottom.

Yield and production

MRD produces medium sized, oblong fruits that are generally bigger than those of the Malayan Yellow Dwarf. The average fruit weight ranges from 668 g (in Brazil) to 1080 g (in Vanuatu). Inside the fruits, the nuts are almost spherical and weigh from 443 g to 755 g on average.

Under ideal agronomic conditions, MRD starts flowering on the second to the third year and may produce about 70-90 fruits per palm per year (without irrigation).

MRD is mainly an ornamental palm, planted in homegardens. Water from young nuts is sweet and tasty, but not as sweet as some green Dwarfs. The albumen is thin and gives rubbery copra. MRD is sensitive to drought and is subject to alternate bearing.

Other topics

The MRD is tolerant to the Lethal Yellowing Disease (LYD) of Jamaica (Romney 1980) but sensitive to the LYD found in Tanzania and Ghana.

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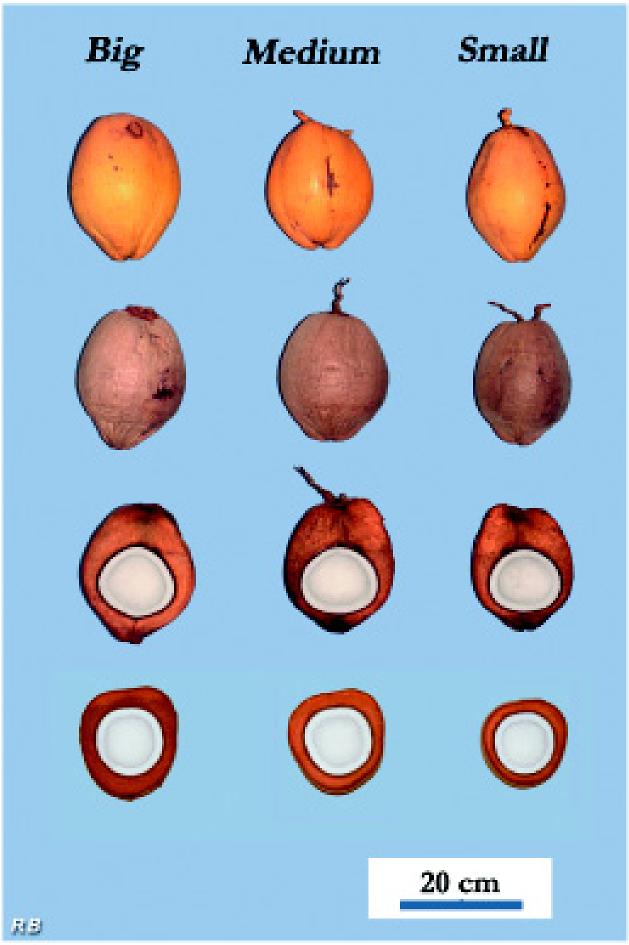
Malayan Red Dwarf (MRD)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Cameroon Red Dwarf (CRD)[2]

The variety Cameroon Red Dwarf (CRD) was introduced in Benin in 1960 and crossed with the West African Tall (WAT) to produce hybrid PB 111 (CRD x WAT). As with MYD, the CRD is also used as ornamental tree in Benin households.

History and description

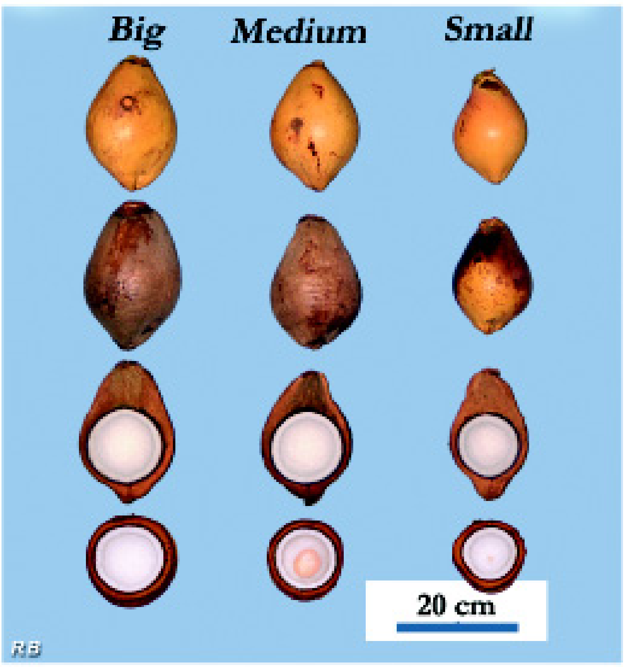
The CRD used as parent variety in the trials were produced from nuts collected in the Kribi region of Cameroon. According to historical accounts, this variety may have been introduced into the country by American missionaries, but it is also possible that it was introduced by the Germans during World War II from the Pacific. The CRD has a long rachis inflorescence and pale orange sprouts, leaf stalks and inflorescences. Its fruit is yellowish in colour.

Growth and production

The CRD is generally shorter in height compared to MYD or the Malayan Red Dwarf (MRD). It also has a relatively slow rate of growth at only 0.25 m/year. The CRD is a direct autogamy type, has a lengthy female phase, a complete overlapping of male and female phases, and a female phase starting very shortly before the spathe opens. The CRD is precocious and flowers at 40 months after field planting and its fruits could be harvested after 54 months. Under good growing conditions, the CRD can produce a mean of 26 female flowers per inflorescence and bear an average of 98 nuts per palm per year or about 13.7 bunches per tree per year. The CRD has a better nut composition compared with MRD, has a bigger nut size than MYD and has higher oil and dry matter contents than the Equatorial Guinean Green Dwarf (EGGD).

[2] From Nuce de Lamothe, M. de and F. Rognon. 1977. Les cocotiers nains à Port Bouët (Côte d'Ivoire). I. Nain Jaune Ghana, Nain Rouge Malaisie, Nain Vert Guinée Equatoriale et Nain Rouge Cameroun. Oléagineux, 32.

Cameroon Red Dwarf (CRD)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Rennell Island Tall

By R. Bourdeix, J.P. Labouisse and P. Batugal

History and description

RIT has a bulky stem that starts with a very large bole. Its leaves are quite short when considering its large stem. The inflorescence is wide, with a long peduncle, and bends quite easily after opening.

Identification

Controversy remains about the numerous seednuts collected from the Rennell Island and sent to other countries. Dr. M.A. Foale, who visited Rennell Island in 1964, said that the true-to-type RIT, with big and pointed fruits, is found mainly around the volcanic lake on the eastern part of the island. In other places, such as the coastal area, there is a mix between RIT and the ordinary type, known as the Solomon Island Tall, which has smaller, oblong-shaped fruits.

The fruits of RIT are among the biggest in the world. The fruit shape is quite variable, from oblong to pear-shaped. Some of the fruits have a long tit or lug at the bottom, which is unique to RIT. The colour of the young fruits range from green to brown-red, although yellow or orange ones are occasionally found. The fruits have high solid albumen and free water contents. Inside, the nut is teardrop-shaped, pointed at the germination side. On the opposite side, the nut is often terminated by a sort of shell point of about 10 mm long that grows inside the husk.

Yield and production

The fruit weight ranges from 1443 g in Tanzania to 1707 g in Côte d'Ivoire, while the fresh albumen weight varies from 491 g in Tanzania to 593 g in Thailand. In Côte d'Ivoire and the Philippines, the fruit yield is about 48 and 78 fruits per palm per year.

Other information

RIT is tolerant to the phytoptora diseases in Côte d'Ivoire and Indonesia. On the other hand, it is sensitive to the Lethal Yellowing Disease in Jamaica, Tanzania and Ghana.

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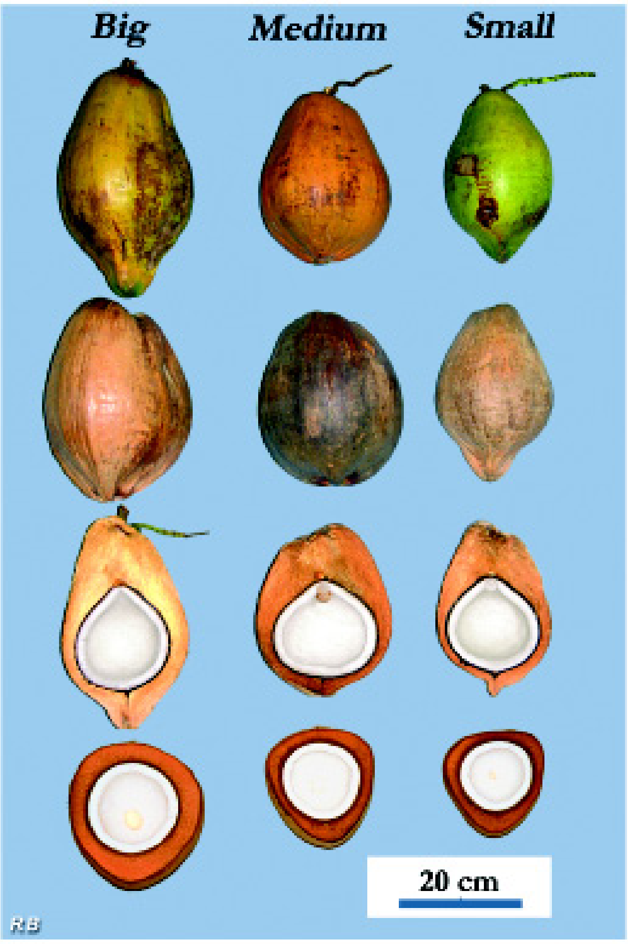
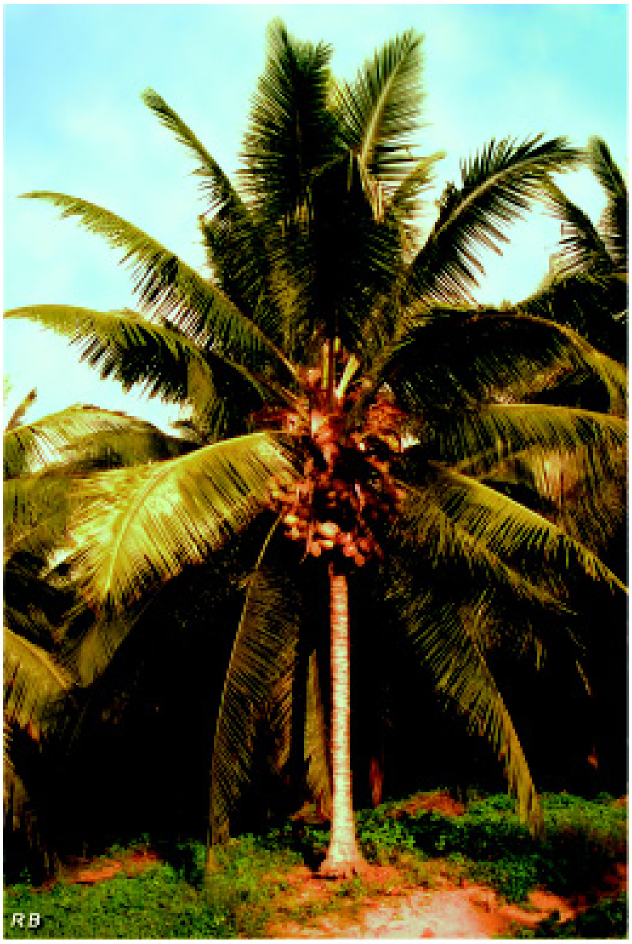
Rennell Island Tall (RIT)





Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Sri Lanka Tall (SLT)

By J.M.D.T Everard, S.C. Fernando and R. Bourdeix

Identification

The Sri Lanka Tall (SLT) belongs to the same group of Talls originating from India and Africa. Compared to West African varieties, it produces fruits that, although oval, are heavier and of better composition, with more meat and less husk. Ripe fruits do not have the equatorial belt, a kind of pleat in the husk epidermis, which is frequently found in West African Talls. The stem is larger in diameter (by 8%) and has tighter leaf scares (by 8%). The leaflets are also narrower by about 9%.

Yield and production

SLT starts flowering, on average, just before its sixth year. It starts bearing at seven years, with 24 fruits per palm per year on average. From 8 to 12 years, production fluctuates between 40 and 50 fruits per palm per year; it then continues to increase, reaching 76 and 102 fruits at 16 and 17 years, respectively. The fruits weigh an average of 1349 g and contain a nut weighing 827 g. Once dried, the 436 g kernel gives around 270 g of fairly oil-rich copra.

Other information

Controversy over the type of variety to be disseminated – hybrid or Tall coconuts – has been raging in Sri Lanka for some time, where a hybrid from the Green Dwarf and the Sri Lanka Tall, CRIC 65, is distributed. Farmers, who have only cultivated Talls for centuries, did not take openly to this new hybrid. According to them, the husk fibres of the hybrids did not have exactly the same characteristics, the wood was of poorer quality and the flavour of the meat was less pleasant. However, in terms of yields expressed in terms of number of nuts or meat weight, CRIC65 has been shown to be better than CRIC 60 - the improved Sri Lanka Tall. CRIC 65's superiority is particularly expressed in the first 12 years. In the 1990s, Sri Lankan researchers designed an original experiment intended to select coconut palms with greater drought resistance. Embryos were removed from seednuts of variety CRIC 60 and transferred to test tubes containing culture media with high concentrations of salts to simulate drought. The few embryos that survived were grown and removed from the tubes. Some have reached adulthood, which are currently being assessed for their drought resistance.

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Sri Lanka Tall (SLT)

Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Tagnanan Tall (TAGT)

By R. Bourdeix, G. A. Santos and R. L. Rivera

History and description

The coconut plantations of the Philippines owe much to a royal edict from the court of Madrid which, in 1798, required each adult to plant 200 square feet of land with coconut. The Tagnanan Estate farm, from which the Tagnanan Tall (TAGT) came, is located in Davao, Mindanao, Philippines.

In the 1940s, this farm was a plantation of abacas, a plant similar to banana whose fibre is used to make ropes and fabrics. At the end of the war, the land was purchased and converted into a coconut plantation, after a virus had decimated the abacas. The necessary seednuts were taken from coconut palms on the shore next to the plantation. According to some inhabitants, the palms were brought from Indonesia by an American settler. Later, the plantation, renamed Tagnanan, was divided among more than 300 Filipino farmers.

Identification

TAGT is a typical Southeast Asian Tall variety. It is a robust palm, which starts flowering quite late. Its massive stem rises very straight from a marked bole. The fronds are long and the inflorescences large. Its large round fruits contain a large proportion of free water and a thin husk. Production continues to increase 15 years after planting, and can reach high levels. It is very difficult to visually differentiate between TAGT and other Asian varieties with similar morphology.

Vertical growth is quite heterogeneous and stronger than that of African Tall palms. The fruits are rounded, often wider than they are long, and rich in free water. They vary in colour from green to reddish-brown, but reddish-brown seems to be the most common. They often have a short, pointed distal nipple. With a thin husk and quite thick meat, fruit composition is excellent, even more so since parents for hybridization were chosen for these criteria. The inner nut is very rounded and wider than it is long. It differs from that of the Malayan and Panama Talls, for example, in which the proximal pointed part of the nut forms an angle at the germination 'eyes'.

Yield and production

Measurements taken at the Tagnanan estate indicate a fruit weighing 1929 g and containing 310 g of copra. In the best plots, the number of fruits produced reaches 94 per palm per year.

Other information

TAGT transmits good tolerance of nut fall and bud rot caused by fungi of the genus Phytophtora. After 15 years of studies at the Philippine Coconut Authority (PCA) Zamboanga Research Centre, nine locally-produced coconut hybrids and one local Tall were selected from the collection and a pool of 67 hybrids established in 11 genetic trials by the PCA. The hybrid released to farmers under the commercial name PCA 15-2 is a cross between the Malayan Red Dwarf (MRD) and TAGT. PCA 15-4 is another hybrid between the Catigan Green Dwarf (CGD) and TAGT.

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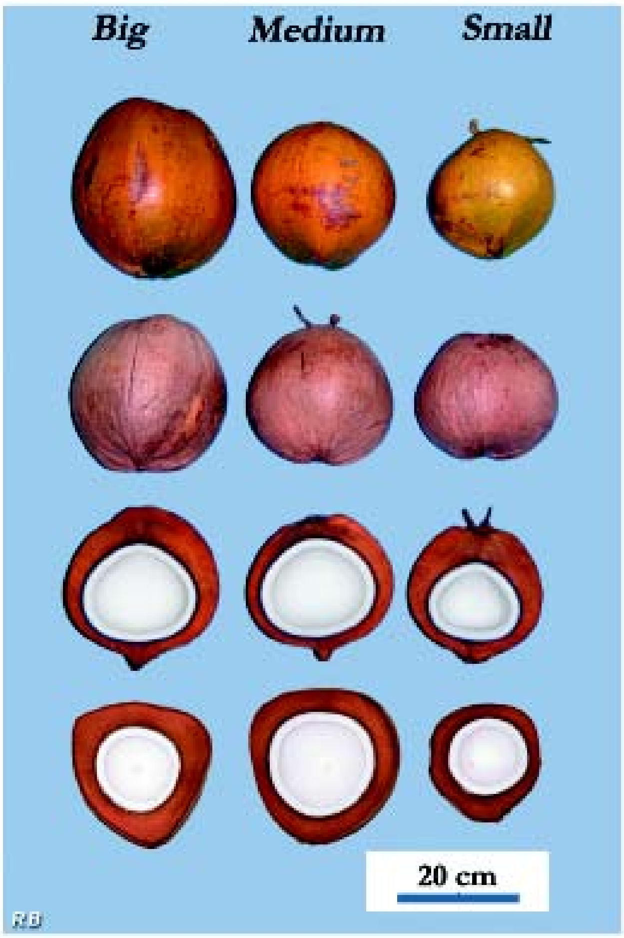
Tagnanan Tall (TAGT)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

West African Tall (WAT)[3]

The West African Talls (WAT) used as parent materials for producing hybrids in Benin are maintained in plantations and were obtained by mass selection from old stands of WAT along the coastal region of Ouidah where they were first introduced around the 17th century. The WAT now planted in Benin possibly came from India and Mozambique. From the Cape Verde Islands where the first palms were probably planted, it was introduced into the African Coast and Latin America. The resemblance between WAT and the Mozambique Tall (MZT) may perhaps contribute to locating the precise origin of WAT.

Growth and production

The WAT has the slowest growth rate mainly due to a slower leaf emission than other varieties. Its fruits can either be green or brown and are oblong-shaped (i.e., polar diameter greater than its equatorial diameter).

The WAT has a short female phase without overlapping by the male phase of the same inflorescence; there is strict allogamy. Although generally precocious, the WAT is sensitive to ecological conditions. WAT begins to flower at five years after planting and begins to produce fruits a year after (at age 6).

The WAT produces about 13 to 14 bunches per palm per year, although around 3-5 bunches may not produce fruits. On average, there are about 28 female flowers per bunch. This variety produces an average of 92 nuts per palm per year, but under good agronomic conditions WAT palms could produce more. Similar to MZT, the WAT has good albumen as well as oil contents. For every 100 g of albumen, the WAT produces about 10.2 g of oil.

[3] From Nuce de Lamothe, M. de and F. Rognon. 1977. Les cocotiers nains à Port Bouët (Côte d'Ivoire). I. Nain Jaune Ghana, Nain Rouge Malaisie, Nain Vert Guinée Equatoriale et Nain Rouge Cameroun. Oléagineux, 32.

West African Tall (WAT)

Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Vanuatu Tall (VTT)

by R. Bourdeix, J.L. Konan and J.P. Labouisse

History and description

Coconut is believed to have existed in Vanuatu for at least 5000 years, or 2000 years before the first known human settlements. The coconut groves underwent substantial extension at the beginning of the 20th century. Although the production of the crop has been on the decline, copra and coconut oil remain as the country's top exports.

The Vanuatu Tall (VTT) is a heterogeneous population, notably in terms of vertical growth and fruit morphology. The stem is slender but is broad at the base. It bears numerous small fruits, weighing 750 to 900 grams each depending on growing conditions. They are slightly oblong, rarely round. The nut, under a usually thin husk, ranges in shape from round, to broader than it is long, or the opposite. It weighs from 500 to 650 grams depending on the site and usually contains thick meat that gives from 140 to 200 grams of copra. Nut germination is very rapid, taking only three months on average.

Identification

Tall type coconut palms that produce fruits as small as those of the VTT are rare, apart from the Indo-African varieties. Compared to the latter, the fruits of the VTT are not so oval - seen from above, their cross-section is clearly less triangular. Dry VTT fruits often retain a smooth, regular epidermis, which is very different from the wrinkled appearance of many other varieties.

Yield and production

The VTT starts bearing very early and can flower as early as three years after planting, although it usually takes four to five years. Adult palms produce between 60 and 100 nuts per palm per year under suitable conditions. In Brazil, on poor sandy soil, annual production has not exceeded 10 nuts per palm.

Other information

Until 1965, nobody suspected the existence of a serious coconut disease in Vanuatu. It was only when exotic varieties were imported to launch a breeding programme that the disease was discovered. The new varieties imported from overseas began to die. The disease, called 'foliar decay' (FD), is caused by a virus. Only VTT resists this disease, which has remained confined in the archipelago. This situation has necessitated quarantine measures forbidding planting material exports from Vanuatu to other coconut growing countries. Research now proposes several breeding materials with FD tolerance: the improved VTT, the Vanuatu Red Dwarf x VTT hybrid, and the VTT x Rennell Island Tall hybrid. The VTT has also performed well with respect to types of lethal yellowing disease that are rife in Ghana. Its hybrids with two Dwarfs – the Malayan Yellow and the Sri Lanka Green – have been disseminated (or are in the process of being so) in Ghana. In Côte d'Ivoire, the hybrid between the VTT and the West African Tall is currently undergoing improvement.

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Vanuatu Tall (VTT)

Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Palu Tall (PUT)

By: M.A. Tulalo and R.H. Akuba

History and description

From 1973 to 1975, an extensive survey of coconut germplasm was carried out in selected areas in 11 provinces of Indonesia the Research Institute for Coconut and Other Palmae (RICP). The Palu Tall (PUT) was first identified and collected at Bangga-Palu District, in the central part of Sulawesi Island.

This variety is described as high yielding by local farmers. PUT produces big round fruits with very low husk content. Its fruits are mainly mainly green, although fruits with brown to yellow-brown tints can also be found. Its stem is thick with a well-developed bole of about 179 cm girth. Its leaves measure 7.3 m on average, with large and thick petiole.

Yield and yield components

In Indonesia, the first inflorescences open five years after planting. Its first fruits could be harvested within the sixth year. Normally, at the adult age, the variety yields from 80 to 100 fruits per palm per year, depending on existing environmental factors and agronomic practices. The composition of the fruit is as follows: weight - 1703 g; weight of nut - 1334 g; weight of meat - 537 g; and copra produced per nut - 303 g, with 69% oil content.

Identification

PUT is one of the Tall varieties in the South East Asia region producing big round fruits and having a thick straight stem with large bole. Morphologically, it is quite difficult to differentiate PUT from the other Tall varieties found in the same region such as the Tenga Tall (TGT) or the Tagnanan Tall (TAGT) of the Philippines.

Other information

PUT is resistant to drought because of its high epicuticular wax and leaf oil contents (Akuba *et al*. 1998). It is also resistant to bud rot disease. Based on the chemical characteristic of its meat and water, the PUT is ideal in producing coconut milk, copra and oil. PUT has a low fosfolipid content, is high in carbohydrate and protein, but low in sugar and galactomanan contents (Tenda *et al*. 1998). PUT is used as male parent in producing the hybrid Khina-3 in Indonesia.

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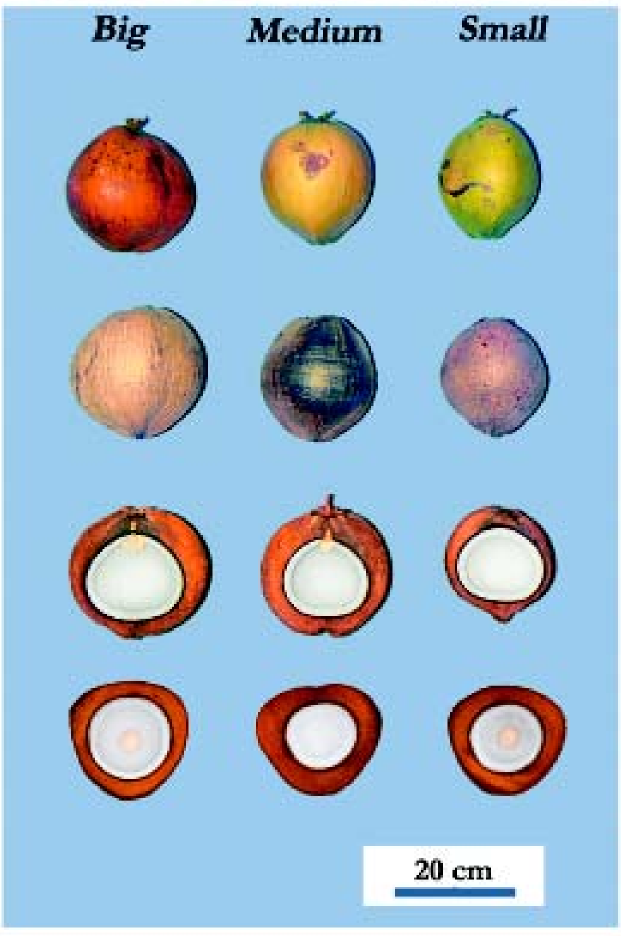
Palu Tall (PUT)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD and Jeffrey Oliver, COGENT*

Tenga Tall (TGT)

By H. Novarianto and H.G. Lengkaey

History and description

Tenga Tall (TGT) derived its name from a village in Minahasa District, North Sulawesi, Indonesia, where the variety was originally found by Indonesia researchers. It is one of the varieties collected during the first survey of Indonesia coconut germplasm in early 1970. The survey, which was led by Dr. D.V. Liyanage of the then Research Institute for Coconut and Other Palmae (RICP), was carried out in selected areas in 11 provinces. The variety was selected because of its desirable characters of high yield of copra per palm. When the survey was conducted, the original TGT population was already about 70 years old.

TGT is characterized by fast stem growth, with the palm usually reaching a height of about 11.4 m. It also has a big bole, with a girth of about 190 cm. The leaves measure 6.3 inches on average. Indonesia. The colour of its petiole is mostly green, the same colour as that of its stalk. Its inflorescences are long. Reproduction is predominantly allogamous. Fruits are mostly green, although some palms have been observed to have green-brown coloured fruits, which are round and have thin husks. Sometimes the equatorial diameter of the fruit is larger than its polar diameter, giving the fruit a somewhat flat appearance.

By its appearance, TGT is quite difficult to differentiate from other related Tall varieties coming from the same region such as, for instance, the Palu Tall (PUT).

Other information

TGT is known to be tolerant to drought and budrot disease. Its hybrid with Nias Yellow Dwarf (NYD), known as Khina-1, is also resistant to budrot disease. TGT fruits are very suitable for the producing copra, cooking oil and desiccated coconut. The shell is also ideal for making charcoal.

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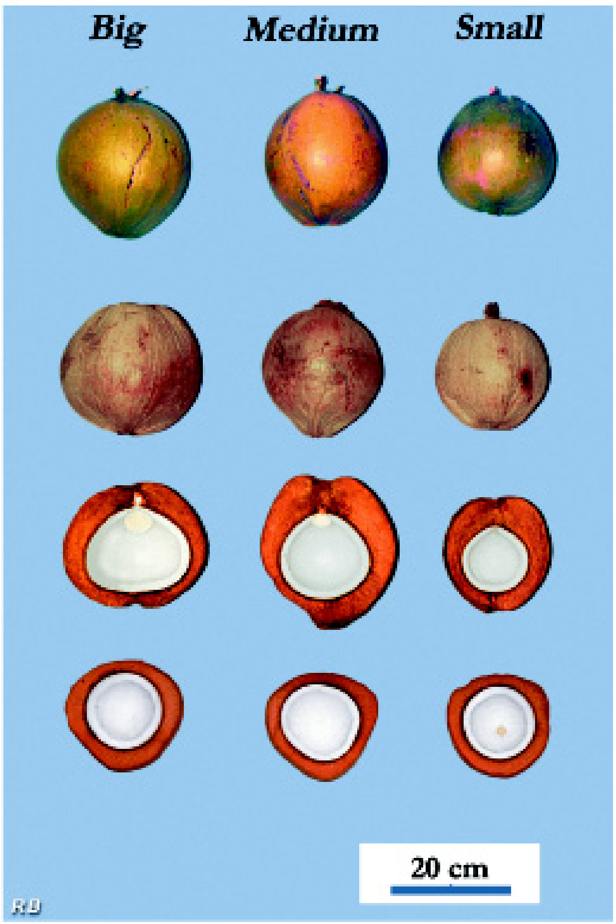
Tenga Tall
TGT



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Coconut hybrid trials in Benin

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Introduction

As with other countries in the West African region, coconut is considered the most economically important perennial oil crop in Benin. The crop is largely believed to have been introduced into the country by Portuguese sailors in the 16th century and planted mostly along Benin's coastal region, where most of the coconut plantations are still located today. The most common variety planted is the West African Tall (WAT). The WAT was most probably introduced from Mozambique. Additionally, variety was first planted in the country at Ouidah around the 17th century. Aside from WAT, other varieties grown in Benin include the hybrid PB 121, which is a cross between the Malayan Yellow Dwarf and the West African Tall (MYD x WAT), and, less extensively, PB 111 which is a cross between the Cameroon Red Dwarf and the West African Tall (CRD x WAT).

To improve the cultivation of coconut, the Institute of Research on Oil and Oilseed (IRHO), a French institute dealing on oil palm development in Benin, began research on the genetic improvement and cultural practices on coconut in the early 1940s. To support this mandate, IRHO established two coconut research stations in Seme-Podji and Port Bouet in Côte-d'Ivoire in 1946 and 1952, respectively.

The total area planted to coconut in the country is estimated at 15 000 ha, about 90% of which is tended by smallholder farmers with average farm sizes ranging from 0.5 to 1.0 ha, although there also exists some large scale plantations or estates varying in sizes from 5 to 50 ha each. Some of these smallholder farmers also rear cattle in their coconut farms, while others grow intercrops like cassava, maize, bean and groundnut as staple food while their coconut palms are still young. Intercropping allows for fast growth of coconut palms, better precocity and improves productivity because of improved maintenance. In the Benin experience, the farming system which ensures the best growth and the best development of the coconut palms is one which integrates vegetables as intercrops (Figure 1) because of the added minerals and livestock raising as source of manure (organic) fertilizer with appropriate irrigation of farm.

Figure 1. PB121 coconut hybrids intercrop with leafy vegetables

Rationale and justification of the project

PB121 and PB 111 are known as high-yielding hybrids but their yields vary widely depending upon the cultivation conditions. In a research station where management practices (i.e., fertilizer application, pest control, regular weeding) are at optimum level, their yields are substantial as shown in Table 1.

Table 1. Comparative yields of WAT, PB 121 and PB 111 in Benin

Variety/Hybrid	Nuts per palm/year	Oil produced per 40 nuts (litres)
WAT	60-80	
PB 121 (MYD x WAT)	125* 152-160**	3.60
PB 111 (CRD x WAT)	110	3.75

**Without irrigation; **with irrigation*

The potential yields as indicated in Table 1 were achieved in farmers' fields where livestock, particularly cattle, was reared under coconut, serving as ready source of organic (manure) fertilizer. In Benin, both immature and mature nuts are harvested – the former for drinking and the latter for producing oil. The immature nuts are either sold to traders or by women in town markets or by the roadsides. Generally, the young nuts are more preferred by people and are therefore more expensive than mature ones. On the other hand, oil produced from mature nuts is sold in bulk to neighbouring countries such as Nigeria and Togo while a small percentage is consumed locally. Aside from its fruits, the other parts of the coconut are used for domestic needs like home fencing and roofing (leaves), house construction (trunk as lumber) and fuel for cooking (shell and husk).

As in many other coconut producing countries, low farm productivity has been a major constraint in profitable coconut production in Benin. To address this, Benin, along with five other countries (Côte d'Ivoire, Tanzania, Brazil, Jamaica and Mexico), participated in one component of the CFC-funded project entitled "Multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean". The project, which was coordinated by IPGRI-COGENT, was particularly relevant to Benin because of the following:

- Low yield of local coconut varieties;
- Proliferation of old and senile coconut stands; and
- Lack of support for varietal/ hybrids development from the government's extension service which focuses mainly on staple food crops.

The multilocation trials aimed to address these by:

- Assisting each participating country to identify suitable high-yielding varieties/hybrids with high adaptation to prevailing local conditions; and
- Estimating the genotype by environment (G x E) interaction which will serve as guide to the application of the results to other countries with similar cultivation conditions.

In the long run, it is expected that the provision of improved and adapted planting materials, particularly coconut hybrids, will contribute to increased coconut production and hence improve the income and well-being of small-scale coconut farmers.

Research methodology and results

One hundred and fifty (150) seednuts of six promising hybrids (MRD x TAGT, MYD x WAT, MRD x VTT, CRD x RIT, VTT x TAGT, and SLT x TAGT) were produced in Côte d'Ivoire and shipped by land to Benin on 25 November 1999. The seednuts of three local hybrids (CRD x WAT; MYD x PNT; and CRD x TAT) were produced at the Sèmè-Podji Station of L'Institut national des recherche agricoles du Bénin (INRAB). The fourth local hybrid, PGD x VTT, was produced in Côte d'Ivoire because of lack of PGD palms in Benin (see Annex 1 for the description of the parents of the local hybrids). This first batch of seednuts was planted at Sèmè-Podji Station in May 2000 and the seedlings were maintained in terms of weeding, fertilization and overall agronomic care. Due to the severe drought that affected the first batch of seednuts (Table 2), Benin requested Côte d'Ivoire to produce and send another set of 200 seednuts of each hybrid in 2002.

Table 2. Status of the seedlings planted on the field after the severe drought

Hybrids	Number of seednuts received	Number of seednuts germinated	Seedlings planted on the field	Number of surviving plants in the field (as of September 2004)
A. Received from Côte-d'Ivoire				
MRD x TAGT	150	124	25	5
VTT x TAGT	150	121	30	13
SLT x TAGT	150	121	30	17
PGD x VTT*	150	34	30	8
MYD x WAT	150	120	30	20
CRD x RIT	150	110	30	8
MRD x VTT	150	112	30	12
Subtotal	***1050***	***742***	***205***	***83***
B. Local hybrids				
MYD x PNT	150	147	30	3
CRD x TAT	150	145	30	7
CRD x WAT	150	140	30	8
Subtotal	***450***	***432***	***90***	***18***
GRAND TOTAL	**1500**	**1174**	**295**	**101**

**Also considered as a local hybrid due to its known adaptation in Benin.*

The seedlings generated from the second batch of seednuts were planted at Fonsa, which is 60 km from Sèmè-Podji Station. The site was cleared and laid out for planting during the second half of May 2002. These plants were well maintained; weeding, fertilization and pest control were regularly carried out. Chemical insecticide was applied to control *Oryctes* attacks.

However, due to another severe drought in 2003, a large number of palms died in the field. The remaining seedlings in the nursery were used to replace the dead plants. But because the number of seedlings in the nursery was insufficient to compensate for the dead palms, Côte d'Ivoire was once again requested to send seedlings. Table 3 shows the status of the seedlings received from Côte d'Ivoire in May 2004 and the locally produced hybrids which were planted in the field.

Table 3. Status of seedlings of the imported control and local hybrids planted on the field in May 2004

Hybrids	Number of seednuts		Number of surviving seedlings in the field
	Received	Germinated	
A. Imported hybrids			
MRD xTAGT	182	138	80
VTT x TAGT	201	183	80
SLT x TAGT	200	172	80
PGD x VTT	260	189	80
MYD x WAT	300	251	80
CRD x RIT	300	184	80
MRD x VTT	182	134	29
Subtotal	***1625***	***1251***	***509***
B. Local hybrids/ variety			
MYD x PNT	392	303	36
WAT	160	76	80
CRD x WAT	737	522	80
Subtotal	***1289***	***901***	***196***
GRAND TOTAL	**2914**	**2152**	**705**

Due to the inadequate number of CRD x TAGT seedlings, this hybrid was replaced by the WAT obtained from opened pollination, which was also used to replace other dead plants on the field. The MRD x VTT cross from Côte d'Ivoire and the local WAT showed the lowest number of germinated seednuts, while the MYD x WAT hybrid from Côte d'Ivoire and the CRD x WAT local hybrid had the highest number of germinated seedlings.

Vegetative data of the first and second batches of planted seedlings

Early vegetative data was not gathered from the second batch of planted seedlings because many of the plants died due to a severe drought, intermittent waterlogged conditions which caused slow growth and the *Oryctes* beetle attack on seedlings. These also produced plants with various early growth levels that cannot be compared for analysis. Therefore, vegetative growth data can only be collected in a few more years when the plants have grown sufficiently to be able to generate meaningful scientific data that could be logically compared and analyzed.

Soil characteristics of the trial site

Soil samples from the trial site at Fonsa were analyzed for physical and chemical properties (Table 4). Five different sample units were analyzed. The results showed that there is heterogeneity in the soil structure and chemistry of the test site. Although this situation does not allow a homogenous development of the seedlings, a suitable statistical analysis will be developed to address this deficiency.

Table 4. Physical and chemical characteristics of the soil samples at Fonsa

Physical and chemical components	Unit 1	Unit 2	Unit 3	Unit 4	Unit 14a
0-2µ %	6.17-7.66	2.02-1.27	2.50-2.25	1-2.1	2.80-0.75
0-20µ %	3.86-2.81	0.25-0.00	0.25-0.00	0.00-0.00	1.75-0.100
20 – 50µ %	1.23-0.25	0.25-0.00	0.60-0.00	0.00-0.00	0.24-0.100
50 – 200 µ %	47.93-32.13	44.13-51.09	22.56-21.50	53.75-49.35	26.81-18.85
200 – 2000 µ %	39.31-54.03	51.14-47.67	73.11-76.18	44.64-47.85	66.25-78.29
N (%)	0.19-0.20	0.081-0.016	0.025-0.008	0.36-0.22	0.185-0.028
P (ppm)	3	4-8	1.2	2-7	4-2
Kméq/100g	0.60	0	0.10	0	0
C/N	8.4-12.4	8.8-8.8	8.4-8.6	8.0-8.0	8.2-8.6
O.M.	2.85-4.33	1.22-0.25	0.37-0.21	0.62-0.39	2.61-0.42
PH	5.4-5.7	4.3-4.7	5.4-5.72	4.7-4.1	4-4.6
Exchange bases(meq/100g)	5.1	1->1	2-1	1->1	5-1
Ca(meq/100g)	3.2	0	1.2	0	0
Mg(meq/100g)	2.35	0	0.60	0	0
CEC(meq/100g)	<10	0	<5	0	0
Clay (%)	6.17-7.36	2.1-2.7	2.25-2.75	1.50-2	0
Sand (%)	0	96-99	0	96-98	96-98
Silt (%)	0	0	0	0-2	0-2

Climatic and rainfall data

In the coconut region of Benin, rainfall averages from 1200 - 1400 mm. There are two rainy seasons (April-July and September-November) between two dry seasons (December-March and August-September). As shown in Table 5, the rainfall patterns were not consistent from years 1985-2004. Therefore, an irrigation system was installed to sustain the coconut hybrids cultivation during the initial years.

Table 5. Climatic data in the project site from 1985 to 2004

Year	Rainfall (mm)	Number of days with rain	Annual mean Temperature (°C)	Relative Humidity (%)
1985	1392.2	83	28.2	84.6
1986	991.4	68	27.3	81.9
1987	1742.0	100	25.7	82.5
1988	1700.2	102	25.6	83.6
1989	1365.6	96	-	-
1990	1111.0	80	27.6	83.3
1991	1749.9	91	27.5	82.8
1992	1244.5	97	27.1	82.6
1993	1321.2	88	27.5	83.0
1994	1301.4	107	27.1	84.2
1995	1382.0	93	27.4	77.9
1996	1372.2	97	27.3	85.2
1997	1700.2	101	26.8	85.9
1998	1123.3	74	28.1	84.2
1999	1555.9	94	27.2	85.8
2000	1359.7	82	25.5	84.9
2001	1010.6	97	27.4	85.5
2002	1422.4	90	27.2	84.4
2003	1354.6	84	27.5	86.4
2004	1644.3	104	27.5	78.7

The way forward

As earlier mentioned, the two severe droughts which killed a lot of the coconut seedlings under study was a major stumbling block in getting relevant vegetative data to make any accurate scientific analysis and comparison of the hybrids. Since the seedlings planted in the field were too young when the project ended in December 2004, it was deemed too early to make any conclusions regarding the hybrids' performance. Instead, the Government of Benin pledged that it will continue to support the trials in Fonsa until such time that the coconut seedlings planted there would be mature enough to reveal significant and useful data about their performance and suitability under Benin conditions from which a reliable G x E interaction analysis could be based upon.

At any rate, the project, based on its initial findings, recommends the following to coconut farmers in Benin:

- Intercrop vegetables under coconut in their fields because of the added benefits of cover crop and additional income and food source;
- Integrate livestock raising under coconuts for added income and improved soil conditions due to organic manure;
- Regularly water their seedlings especially during the dry season in order to achieve their full productivity potential;
- Carry out mulching using coconut husks to increase the soil's water retention ability; and
- Look into other high-value uses of the different parts of the coconut to maximize farm productivity and income.

Annex 1. Description and pictures of the parent varieties of local coconut hybrids used in the trials in Benin[1]

Panama Tall (PNT)

R. Bourdeix, L. Baudouin, and J.L. Konan

Description

Fruits of the Panama Tall are almost round, both longitudinal and cross section, and weigh about 1483 g on average. They contain a nut that is also round, sometimes slightly conical at the end with the germination 'eyes', and weighs about 1020 g. The kernel weighs 473 g and 263g of oil-rich copra. The husk of immature fruits sometimes displays the intense pink colouring as that of the Pilipog Green Dwarf from the Philippines.

The Panama Tall from two different origins- Aguadulce and Monagre - are conserved in Côte d'Ivoire. The vertical growth of palms from Aguadulce is slightly more rapid, but morphological differences between the two are slight. However, molecular biology analyses have revealed that the Monagre type is more closely related to the famous Panama Tall coconut palms from the Agualta Vale plantation in Jamaica. The variety known as the "Jamaica San Blas" in India is also a Panama Tall.

Yield and production

The palms start bearing late. On average, flowering begins 76 months after planting. As observed in Côte d'Ivoire, this variety produces an average of 12 bunches with 31 fruits per palm per year on adult palms (9 to 12 year average).

Other information

Panama Talls had their moment of glory in the 1980s, when studies conducted in Jamaica concluded that, along with their hybrids, they were among the varieties with greatest tolerance to Lethal Yellowing. In 1969, the so-called 'Jamaica Tall' local variety accounted for 90% of the three million coconut palms in Jamaica. However, 26 years later, stands of the variety were destroyed by Lethal Yellowing (and also by cyclones), and now accounting for no more than 1% of total coconut plantings. The rest (about 6 million palms) comprised 1% Panama Talls, 49% Malayan Dwarfs, and 49% Panama Tall hybrids with the same Dwarfs (called Maypan or Mapan). Despite initial successes, the hybrids started dying by the thousands in the mid-1990s. Experts are still not sure of the reasons for this new catastrophe: was the tolerance observed in field trials really of genetic origin? Was the planting material supplied to farmers really true-to-type? Was a new pathogen strain (a phytoplasma) accidentally introduced? Or did the pathogen strain mutate? Or was the strain that is active today already present from the beginning and was somehow activated and has now taken over as the only one capable of attacking the new varieties? Panama Talls have also been observed to be susceptible to other types of Lethal Yellowing, notably in Tanzania.

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[1] For the description and pictures of Malayan Yellow Dwarf (MYD), Cameroon Red Dwarf (CRD) and West African Tall (WAT), please refer to Annex 1 of "Coconut hybrid trials in Cote d'Ivoire" in this book, pp. 32-51.

Panama Tall Monagre (PNT02)

Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Tahitian Tall (TAT)

By R. Bourdeix, J.L. Konan and K. Ballo

History and description

French Polynesia is made up of 118 islands and atolls spread across more than four million square kilometres of the eastern Pacific Ocean. It includes five archipelagos: the Austral Islands, the Marquesas Islands, the Tuamotu atolls, the Mangareva Islands and the Society Islands. It is in the last island group, on Tahiti, that the Tahitian Tall (TAT) was first identified and collected.

Identification

Along with the Niu Leka Dwarf, TAT is the variety that produced the largest number of spikelets per inflorescence in studies in Côte d'Ivoire. The inflorescence is weighed down by the weight of the spikelets, which makes it gradually lean after opening. In Côte d'Ivoire, only TAT originating from the Rennell and the Comoro Islands produce a bole at the base as wide as that of the Polynesia Tall. Some fruits, of average size and excellent composition, have a surprisingly thin husk.

Under good agronomic conditions, TAT grows to become a large palm. It produces numerous fronds that are longer than those of the African varieties, though they have the same number of narrower leaflets.

The fruits vary in shape and colour, and sometimes have a distal nipple. Their weight varies from 1165 g in the Philippines to 1291 g in Côte d'Ivoire. The inner nut also varies in shape - slightly pointed at the end with the germination 'eyes', or are oblong or virtually round. The kernel is generally thick and weighs 429 to 460 g.

Yield and production

In Côte d'Ivoire, TAT starts bearing early. On average, it flowers on its fifth year, with adult palms producing 60 to 70 fruits per palm per year. Yields are better in the Philippines, with 84 fruits per palm.

Other information

The Polynesians, who were great voyagers, took coconuts with them on their boats during their travels. Discoveries, such as Lapita pottery, show that they were in Fiji around 2500 BC, in Tonga in 1100 BC, and Samoa in 1000 BC. They settled in the Marquesas (300 BC), in the Society Islands of which Tahiti is a member (600 AD) and lastly in New Zealand (800 AD). Charles Darwin, during his voyage on the Beagle which led him as far as Tahiti in 1839, once wrote, "After walking under a burning sun, I do not know anything more delicious than the milk of a young cocoa-nut". And there is also the centuries old story of a Portuguese seafarer who exclaimed, on first discovering coconuts, "What a marvellous country, here even the cows lay eggs!"

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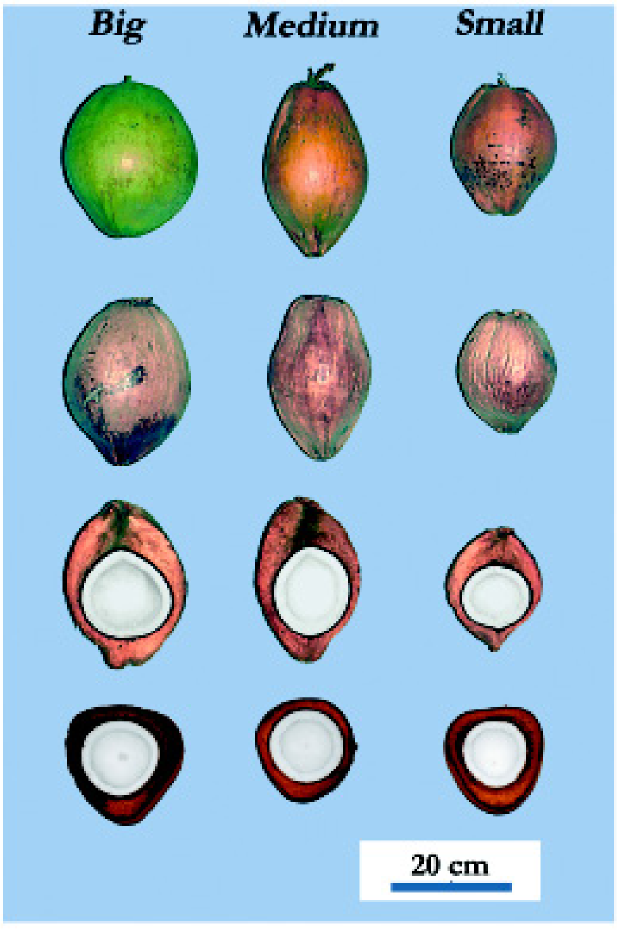
Tahitian Tall (TAT)



*Pictures courtesy of **Dr. Roland Bourdeix**, CIRAD*

Coconut hybrid trials in Tanzania

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Introduction

The coconut (*Cocos nucifera* L.) is the single most important perennial oil crop in Tanzania. The crop is mostly cultivated by about 500 000 smallholder farmers with an average farm size of 0.5 ha. These smallholder farmers contribute 95% of the country's total coconut production of 890 million nuts annually. The major coconut-growing areas include the coastal belt of Tanzania's mainland (about 265 000 ha) and in the islands of Zanzibar (around 550 000 ha). Other coconut-producing areas are Kigoma region, Kyela in Mbeya region and around the shore of Lake Victoria.

Currently, the average coconut yield in Tanzania is estimated at 35-40 nuts per palm per year or about 0.5 ton of copra per hectare. Households in the traditional coconut growing areas consume about 3 to 4 nuts per day. Of the 890 million nuts produced annually, 80% are consumed as fresh nuts in the rural households, 15% are used in the urban areas and 5% are processed into copra. Although the demand for coconut is high, this cannot be met due to low production. Some of the major production constraints include: (1) sub-optimal growing conditions, particularly inadequate and uneven rainfall distribution; (2) incidence of lethal disease (LD) caused by phytoplasma; (3) lack of improved planting materials that are adapted to biotic and abiotic stress conditions; (4) severe attack by pests, particularly the coreid bug, rhinoceros beetle and coconut mite; (5) poor crop husbandry practices; and (6) lack of a comprehensive replanting programme to rehabilitate ageing coconut palms.

Over the past 25 years, the Government of the United Republic of Tanzania has been implementing a National Coconut Development Programme (NCDP) with the objective of promoting coconut production and utilization through a number of research and development interventions. These interventions include: (1) breeding research to identify high-yielding and adapted planting materials; (2) agronomy and farming systems research to develop improved coconut-based farming systems appropriate for small-scale farmers; (3) crop protection to determine efficient pest and disease control strategies against important coconut pests and diseases; (4) establishment of seed farms; (5) improvement of nursery management practices to raise quality seedlings; and (6) development of improved small-scale post harvest technologies.

The main objective of the NCDP is to develop high-yielding, LD-resistant and drought-tolerant coconut varieties**.** The initial strategy was to import hybrids developed in Côte d'Ivoire in order to save on time and cost required for breeding. It was also assumed that some of the introduced hybrids would perform well in the country as these had been tested in Côte d'Ivoire where conditions are similar to that of Tanzania. A total of 22 hybrids were imported and evaluated in agronomic performance and disease resistance trials in six locations. The initial results indicated that the hybrids were more vigorous in growth than the predominantly grown local East African Tall (EAT) population. They came into bearing two years earlier than the EAT and they also showed higher yields. Following these encouraging results, two hybrids, namely the Malayan Yellow Dwarf x West African Tall (MYD x WAT) known as MAWA, and the Cameroon Red Dwarf x West African Tall (CRD x WAT) known as CAMWA, were released in February 1987 for commercial production. However, these hybrids could not sustain their initial good performance because of the relatively dry weather conditions prevailing in most coconut growing areas where they were introduced. By 1990 the hybrids were showing severe symptoms typical of drought stress, and a decision was therefore made to discontinue the production of these hybrids and to put more emphasis on the improvement and planting of EAT.

In 1991-1992, a cross breeding programme was initiated in which individual palms that had survived the LD in the 10-year disease resistance trials were used to produce different hybrid progenies. These were planted at three locations and their performance with respect to yield, LD resistance and drought tolerance were evaluated. The results indicated that these hybrids have good yield potential, but they eventually succumbed to LD under high disease pressure.

Rationale and justification of the project

Although the climatic conditions in many coconut growing areas in Tanzania are classified as sub-optimal for hybrid coconut production, there are certain niche areas which are favourable. These include areas with high water table such as valley bottoms and around homesteads. For instance, coconut hybrids planted under low input conditions in Nga'pa valley, where the water table is high, produced 53% more nuts and 67% more copra than the EAT (Table 1). The same applies to coconuts planted around homesteads, where they occasionally get water from the household.

Table 1. Performance of three coconut hybrids and EAT at Ng'apa Valley, 1992-1997

Treatment	Yield (nuts/palm)					Copra yield (t/ha)				
	1992/93 A	1993/94 B	1994/95 C	1995/96 D	1996/97 E	1992/93 A	1993/94 B	1994/95 C	1995/96 D	1996/97 E
CRD x RIT	79	75	76	72	73	2.35	2.45	2.28	2.09	1.60
MRD x WAT	77	68	70	68	70	2.22	1.78	2.0	1.88	1.49
MYD x PYT	41	40	63	58	59	1.40	1.23	1.7	1.52	1.22
EAT	26	19	57	56	58	0.75	0.59	1.62	1.37	1.11
Mean	**56**	**50**	**66**	**64**	**65**	**1.68**	**1.51**	**1.90**	**1.71**	**1.35**

A, B, C, D and E represent 108, 120, 132, 144 and 156 months after planting, respectively

It is against this background that Tanzania agreed to participate in the 'Multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean' which was funded by the Common Fund for Commodities (CFC) and coordinated by IPGRI/COGENT. The objectives of the project were: (1) to assist each of the participating countries (Jamaica, Brazil, Mexico, Benin, Côte d'Ivoire and Tanzania) in identifying suitable high yielding varieties and hybrids with good adaptation to prevailing local conditions; and (2) to estimate genotype x environment (G x E) interaction, which would serve as a guide in the application of the results to other countries with similar conditions.

Research methodology and results

The trials were carried out in two batches. The first batch of seednuts consisting of six hybrids: Malayan Yellow Dwarf x West African Tall (MYD x WAT), Malayan Red Dwarf x Rennell Island Tall (MRD x RIT), Malayan Red Dwarf x Vanuatu Tall (MRD x VTT), Cameroon Red Dwarf x Tagnanan Tall (CRD x TAG), Vanuatu Tall x Tagnanan Tall (VTT x TAG), and Sri Lanka Tall x Tagnanan Tall (SLT x TAG) were produced in Côte d'Ivoire and used as common test materials for all the six country trials. Three local hybrids - East African Tall x Pemba Red Dwarf (EAT x PRD), East African Tall x Rennell Island Tall (EAT x RIT), and East African Tall x Vanuatu Tall (EAT x VTT) - and one local variety, East African Tall (EAT), were produced by hand pollination at the Chambezi Research Station in 1999 (see Annex 1 for pictures and descriptions of the parent varieties of the local hybrids). These were sown in the nursery at Chambezi Research Station, and the seedlings planted in April 2000 at Kiberege and Idete prison farms in Ifakara District.

The second batch of seednuts consisted of the same six common hybrids, three local hybrids and one local variety. These were produced and raised in the nursery in 2002. The trial site for the second batch of seedlings was at the Mkuranga Research Station (latitude 7.12ºS and longitude 39.20ºE) located about 50 km south of Dar es Salaam. The site has gentle undulating slope (2%) with reddish-brown sandy clay loam soil (ferralitic arenosol). The area has deep, well-drained soil covered with a natural vegetation of shrubs, trees and grasses, mostly *Cynodon* spp. Land preparation was initiated in 2002 and field planting commenced in April 2003.

Soil characteristics of the trial sites

Soil samples were taken and analyzed for physical and chemical properties at the National Soil Laboratory at Mlingano Agricultural Research Institute in Tanga. Table 2 shows the results of the soil analysis, while the soil profile is presented in Table 3. Results of the analysis, as indicated in Tables 2 and 3, show that the soil has very low organic matter, nitrogen and phosphorous content. To offset this, organic manure (cow dung) was added to the soil during planting.

Table 2. Physical and chemical soil characteristics of the trial site at Mkuranga Research Station

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH (H_2O)	pH (KCl)	OM (%)	N (%)	Ca (%)	Mg (%)	K (%)	Na (%)	CEC (Me/ 100g)	P (ppm)	BS
0-40	78.0	6.0	16	5.8	4.2	1.07	0.10	1.6	0.4	0.24	0.19	4.05	1.64	60
40-61	72.0	4.0	24	6.0	4.1	0.73	0.05	1.0	0.3	0.19	0.13	2.38	1.03	68
61-150	68.0	2.0	30	5.9	4.2	0.54	0.03	1.0	0.2	0.19	0.16	2.42	0.65	64

Note: BS = Base saturation; OM = Organic matter

Table 3. Soil profile of the trial site at Mkuranga Research Station

Layer		Description
A0	0 - 40 cm	Grey (5YR5/1) dry, very dark grey (5YR3/1) moist; sand loam; loose dry, friable moist, non-sticky and non-plastic when wet; weak fine sub-angular blocky; few medium and many fine pores; many fine and few coarse roots; clear diffusing boundary to AB
AB	40 - 61 cm	Red (2.5YR4/6) dry, strong dark red (2.5YR3/6) moist; sandy clay; slightly hard dry, friable moist, sticky and plastic when wet; weak fine and medium sub-angular blocky; common medium and many fine pores; few fine and very few medium roots; diffuse smooth boundary to Bw1
Bw1	61 -150+ cm	Dark red (2.5YR4/8) moist; (2.5YR5/8) red clay loam, slightly hard when dry, friable moist, sticky and slightly plastic wet; medium sub-angular blocky; few medium and many fine pores; very few fine and medium roots; few medium size round shape quartz observed

Climatic data

The average monthly rainfall and temperature distribution at Mkuranga Research Station for the period of 1983-2004 and 1999–2004 are presented in Fig. 1. The long term (1983-2004) average annual rainfall is 1103.9 mm, 52.8% of which fall during the long rainy period from March to May and 27.8% during the short rainy period from October to December. The months of June-September and January-February are marked with severe water deficit, during which the plants suffer from drought stress. The average annual temperature is about 25°C, while the average minimum and maximum temperature is about 20.5°C in June/July and 31.5°C in January/February, respectively.

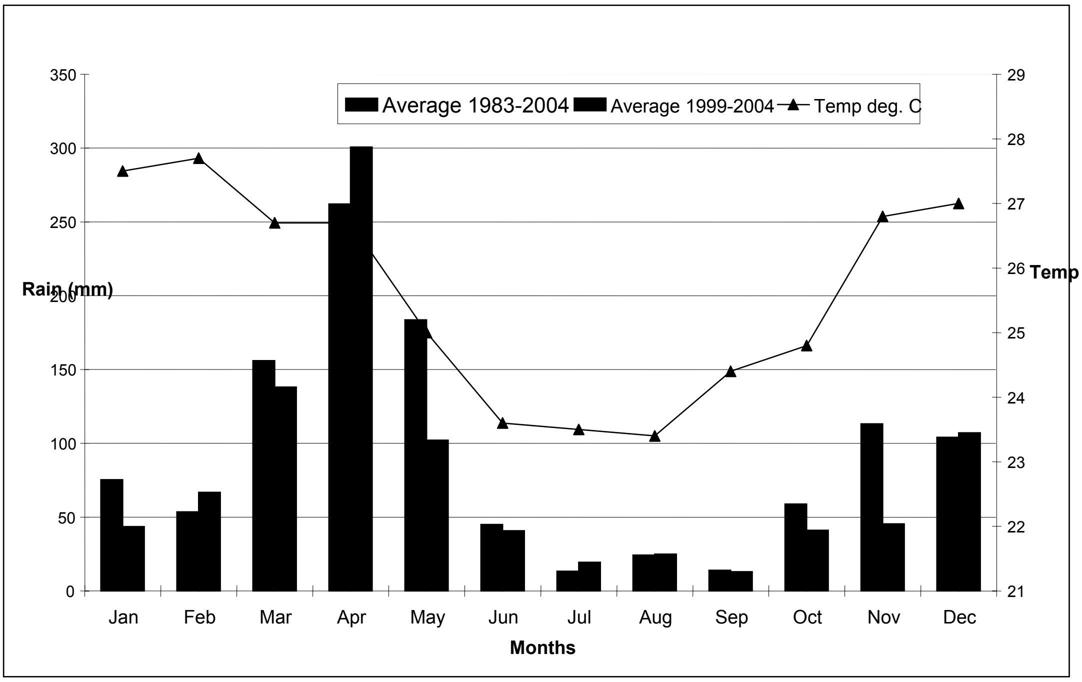


Figure 1. Average rainfall distribution and temperature at Mkuranga Research Station (1983 – 2004)

During the project period (1999–2004), the average rainfall at Mkuranga was 927.1mm, which was about 84% of the long term average (Table 4). The weather condition was extremely dry in 2003 and 2004 during the trials. The total rainfall was only 477.8 mm in 2003, and 898.3 mm in 2004, which correspond to only about 43.3% and 81.4% of the long term average.

Table 4. Rainfall distribution (mm) from January 1999 to December 2004 at Mkuranga Research Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	17.7	63.3	246.5	247.5	161.9	134.3	35.3	43.3	20.4	33.8	65.4	126.5	**1195.9**
2000	0	0	170.9	238.4	58.8	81.3	7.8	31.9	8.9	4.9	122.3	135	**860.2**
2001	58.6	94.5	69.3	314.5	191.4	12.6	2.2	8.2	0	18.2	6.1	45.6	**821.2**
2002	83.7	75.9	156	756	47.3	8.5	64.6	70.6	47.1	0	0	0	**1309.7**
2003	31.5	50.2	123.6	34.4	150.1	51.4	16.5	3.8	0	16.3	0	0	**477.8**
2004	70.1	117.0	62.7	222.0	3.5	21.1	6.4	0	1.7	150.5	65.0	178.3	**898.3**
Avg.	**43.6**	**66.8**	**138.2**	**302.1**	**102.2**	**51.5**	**22.1**	**26.3**	**13.0**	**37.3**	**43.1**	**80.9**	**927.1**

Biotic and abiotic stresses

Drought was the most serious abiotic stress factor that occurred as a result of unfavourable weather conditions during the first two years after planting. To address this, the seedlings were watered at least once a week with about 20 litres of water per seedling. In May 2004, as a measure to conserve soil moisture, the palms were mulched with coconut husks - and bananas were planted within the rows of coconut seedlings in the trial site to provide a favourable microclimate to the coconut plants. A cover crop (*Pueraria* spp.) was also established at the onset of the rains in December 2004. Scouting for *rhinoceros* beetle in the field was done every two days to effectively monitor and control this pest. In September 2004, a trench 1 m wide and 1 m deep was dug around the trial plot to contain the problem of wild pig attacks.

First batch of hybrids for multilocation trials

In March 1999, 150 seednuts each of the six imported hybrids from Côte d'Ivoire were received and sown in the nursery together with the local hybrids. Out of the 900 imported hybrid seednuts, only 266 (29.6%) germinated, of which 160 plantable seedlings were obtained (Table 5). The low germination was due to delay in the shipment of the seednuts from Côte d'Ivoire to Tanzania. On the other hand, 2351 seednuts of the local hybrids were produced, of which 1409 (59.9%) germinated and 1376 plantable seedlings were obtained.

Table 5. Number of seednuts and seedlings of the imported and local hybrids from the first batch

Hybrid/Variety	Number of seednuts		Germination (%)	Number of seedlings		Plantable seedlings
	Sown	Germinated		Normal	Abnormal & off-types	
A. Imported hybrids						
VTT x TAGT	150	41	27.3	23	15	23
SLT x TAGT	150	42	28.0	42	0	42
MYD x WAT	150	77	51.3	67	7	67
CRD x RLT	150	39	26.0	21	9	21
MRD x VTT	150	34	22.7	4	25	4
MRD x TAGT	150	33	22.0	3	24	3
Subtotal	***900***	***266***	***29.6***	***160***	***80***	***160***
B. Local entries						
EAT x PRD	745	441	59.2	430	11	430
EAT x RIT	727	471	64.8	460	11	460
EAT x VTT	574	312	54.4	308	4	301
EAT (o.p.)*	305	185	60.7	185	0	185
Subtotal	***2351***	***1409***	***59.9***	***1383***	***26***	***1376***
GRAND TOTAL	**3251**	**1675**	**51.5**	**1543**	**106**	**1536**

**O.P. = open pollinated*

The first batch of seedlings was planted in April 2000 at Kiberege and Idete prison farms in Ifakara District. In Kiberege farm, the four local entries (EAT x VTT, EAT x RIT, MRD x EAT, and EAT) and one imported hybrid (MYD x WAT) were planted using a randomized complete block design (RCBD) with four replications. In addition, 20 seedlings each of VTT x TAGT and CRD x RIT and 40 seedlings of SLT x TAGT were planted in blocks (without replication) for demonstration purposes.

The trials in Idete farm consisted of the three local hybrids and EAT planted in RCBD with five replications. The remaining seedlings were planted in small on-farm demonstration plots in Pangani district, Tanga region. During the first year after planting at Kiberege and Idete prison farms, more than 50% of the seedlings planted died due to high termite infestation, severe drought, bush fire and damage by wild pigs. Due to the low plant stand, this trial was discontinued.

Second batch of hybrids for multilocation trials

In March 2002, a total of 1642 seednuts of the six imported hybrids were received from Côte d'Ivoire and sown in the Chambezi nursery whereby 1103 germinated (67.2%) (Table 6). With respect to the local controls, a total of 823 seednuts were produced, from which 750 germinated (about 91.1%).

Table 6. Number of seednuts and seedlings of the imported and local hybrids from the second batch

Hybrids	Number of seednuts		Germination (%)	Seedlings		Plantable seedlings
	Sown	Germinated		Normal	Abnormal & off-types	
A. Imported hybrids						
MYD x WAT	400	265	66.3	220	45	220
CRD x RIT	420	244	58.1	216	28	216
VTT x TAGT	198	142	71.7	135	7	135
SLT x TAGT	208	118	56.7	109	9	109
MRD x VTT	208	160	76.9	145	15	145
MRD x TAGT	208	174	83.7	160	14	160
Subtotal	***1642***	***1103***	***67.2***	***985***	***118***	***985***
B. Local entries						
EAT x RIT	198	198	100.0	179	19	179
EAT x VTT	252	240	95.2	239	1	239
EAT o.p.	225	200	88.9	200	0	200
EAT x PRD	148	112	75.7	110	2	110
Subtotal	***823***	***750***	***91.1***	***728***	***22***	***728***
GRAND TOTAL	**2465**	**1853**	**75.2**	**1713**	**140**	**1713**

Field preparation and layout for planting the second batch of seedlings were carried out in February 2003. The work involved digging planting holes with a diameter and depth of 60 cm each and adding one bucket of farmyard manure, 200g of triple super phosphate (TSP) to enhance root development and 20g of Marshal SuScon to prevent termite infestation.

The seedlings were planted in April 2003 in RCBD with five replications. Each experimental plot consisted of 16 seedlings planted at a spacing of 9m triangular. Guard rows were also planted around the border to minimize border effects. In view of the unusually dry weather conditions in 2003 and 2004 (Table 4), it was necessary to irrigate the palms weekly with about 20 litres of water per palm.

Vegetative data for the second batch of seedlings

Vegetative growth data (plant height, number of leaves, leaf length, number of leaflets leaflet length, leaflet width and rachis length) were recorded semi-annually - in November 2003, June 2004 and November 2004 - which were about 7, 14 and 19 months after planting, respectively. During the first seven months after planting, the number of leaves produced ranged from four for EAT and six for both EAT x VTT and MYD x WAT. The number of leaflets ranged from 28 for EAT x RIT to 46 for MRD x TAGT, while the plant height was 103.3 cm for CRD x RIT and 201.8 cm for MRD x TAGT . After 14 months, the hybrid CRD x RIT showed the least vigorous growth while MRD x VTT, MRD x TGT and MYD x WAT were the most vigorous. Table 7 shows the status of vegetative growth after 19 months. Statistical analysis revealed significant differences among the test materials for all growth parameters.

Table 7. Status of vegetative growth of seedlings 19 months after planting

Hybrid/ Variety	Number of Leaves	Palm Height (cm)	Petiole Length (cm)	Petiole width (cm)	Leaflet length (cm)	Number of Leaflets	Leaflet width (cm)	Rachis Length (cm)
EAT x RIT	11.2	311.7	87.1	4.0	77.3	115.4	4.6	157.8
EAT x PRD	11.1	321.7	89.8	4.6	72.5	118.1	4.4	164.9
MRD x VTT	11.7	337.3	86.5	4.2	78.2	131.3	4.8	185.1
SLT x TGT	10.8	310.9	88.6	3.9	79.3	108.9	5.2	162.2
VTT x TGT	10.8	293.2	80.9	3.9	67.2	111.7	4.5	146.5
CRD x RIT	9.5	230.8	66.4	3.0	54.8	97.6	3.5	137.0
MYD x WAT	11.9	308.2	84.7	4.2	82.0	118.1	4.9	162.1
MRD x TGT	11.4	331.9	86.9	4.2	81.7	118.9	4.4	182.3
EAT o.p.	11.0	315.4	88.5	3.9	77.8	112.8	4.5	157.1
EAT x VTT	11.3	321.3	92.3	4.0	75.9	119.2	4.7	163.6
Mean	**11.1**	**308.2**	**85.2**	**4.0**	**74.7**	**115.2**	**4.6**	**161.9**
CV (%)	**9.1**	**11.6**	**10.8**	**14.0**	**8.0**	**11.8**	**15.3**	**14.5**
LSD (at 0.05)	**1.3**	**46.1**	**11.8**	**0.7**	**7.7**	**17.5**	**0.9**	**30.4**

Table 7 shows that during the last 12 months, CRD x RIT produced significantly fewer and shorter leaves than the other hybrids. The hybrids MRD x VTT and MRD x TGT continued to exhibit the most vigorous growth, while MYD x WAT produced the highest number of leaves.

Leaf analysis data of the second batch of seedlings

In June 2004, leaf samples were collected for nutrient analysis. The soil analysis conducted earlier showed low content of N and P. To address this, fertilizer was subsequently applied in April 2004. Later leaf analysis indicated adequate levels of N, P, K and Mg in the leaves (Table 8). However, Ca uptake was low. This might be the effect of low pH and also of antagonism between Ca and Mg. Normally, high Mg content in the soil limits Ca uptake and vice-versa. In terms of micronutrients, the status of Cu and Zn in the leaves was poor, while Fe and B levels were adequate. The Mn content was found to be much higher than the critical level. This excessive uptake of Mn can be attributed to the low soil pH, which ranged from 4.9 - 5.7 in the analysed sub-soil (Table 8).

Table 8. Leaf nutrient analysis of the different varieties in June 2004, 14 months after planting

Hybrid/ Variety	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)	B (ppm)
EAT x RIT	1.81	0.19	1.02	0.29	0.45	2.62	68.4	8.40	761.1	29.4
EAT x PRD	1.85	0.15	0.95	0.36	0.41	2.60	89.8	4.76	750.6	24.6
MRD x VTT	1.53	0.16	0.93	0.39	0.35	2.65	63.7	3.88	761.2	26.9
SLT x TGT	1.77	0.15	1.06	0.29	0.41	2.45	64.6	6.15	710.1	19.5
VTT x TGT	1.92	0.15	0.92	0.37	0.45	2.40	92.8	7.75	790.4	24.1
CRD x RLT	1.56	0.15	0.90	0.39	0.44	2.62	61.4	6.10	804.6	23.9
MYD x WAT	1.85	0.15	0.87	0.28	0.47	2.87	92.8	7.35	821.8	24.0
MRD x TGT	1.83	0.17	0.90	0.31	0.43	2.70	83.3	5.75	687.8	20.5
EAT o.p.	1.69	0.14	0.90	0.42	0.44	2.52	84.1	17.18	775.0	24.5
EAT x VTT	1.77	0.17	0.92	0.33	0.45	3.50	45.1	4.98	735.8	20.8
Critical level	**1.80**	**0.14**	**0.80**	**0.50**	**0.30**	**5-20**	**50-250**	**25**	**20-500**	**20-100**
Mean	**1.76**	**0.16**	**0.93**	**0.34**	**0.43**	**2.69**	**74.70**	**7.23**	**759.80**	**23.80**
CV (%)	**16.5**	**19.0**	**11.2**	**28.6**	**13.3**	**31.9**	**30.5**	**14.5**	**16.4**	**32.0**

Soil nutrient analysis 15 months after planting

The second soil analysis was carried out in June 2004. A comparison of the results in Table 2 (pre-planting) and Table 9 reveals that the soil was still acidic (average pH value of 5.5) and that organic matter and total nitrogen contents were still very low. However, P content has increased more than three times, most likely due to fertilizer application. Nevertheless, the available P content in the soil is still very low. This can be attributed to the low pH conditions, whereby the phosphate ions combined with iron and aluminum to form compounds which are not readily available to plants. The K levels ranged from medium to high and had increased more than two-fold since the first soil analysis. The soil analysis also revealed medium to high levels of chlorine and good C : N ratio (average of 13.8). Whereas, the contents of Ca, Mg, Na, and the values of cation exchange capacity (CEC) and electro conductivity (EC) were very low. The low EC values indicated that the soil had small amounts of sodium.

Table 9. Soil nutrient analysis of the trial site in June 2004, 14 months after planting

Parameter	Replication 1		Replication 2		Replication 3		Replication 4		Replication 5		Mean
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	
pH (H_2O)	5.50	4.90	5.70	5.44	6.07	5.70	5.57	4.93	6.07	5.40	5.53
pH (KCl)	5.13	4.65	5.43	4.93	5.67	5.43	5.20	4.65	5.83	5.20	5.21
Organic Matter (%)	0.84	0.55	0.75	0.49	0.84	0.53	0.67	0.56	0.92	0.44	0.66
N (%)	0.07	0.04	0.08	0.03	0.06	0.04	0.04	0.04	0.10	0.03	0.05
C:N ratio	13.00	14.00	9.70	16.70	14.7	14.70	15.30	16.30	9.30	14.70	13.80
Available P (mg/kg)	8.09	4.91	6.56	1.66	3.64	3.17	6.90	4.22	12.90	2.05	5.41
CEC (Me/100g)	4.30	4.01	4.09	3.89	4.67	3.63	3.01	3.87	4.05	3.94	3.95
Ca (Me/100g)	1.20	0.55	1.33	0.63	1.97	1.13	0.80	0.40	1.87	0.77	1.07
Mg (Me/100g)	0.43	0.30	0.43	0.27	0.33	0.20	0.30	0.33	0.37	0.40	0.34
K (Me/100g)	0.53	0.38	0.60	0.37	0.85	0.54	0.54	0.53	0.58	0.70	0.56
Na (Me/100g)	0.20	0.21	0.02	0.23	0.06	0.04	0.04	0.10	0.03	0.05	0.10
BS (%)	55.00	36.00	58.30	42.30	68.7	55.30	55.30	34.80	50.60	48.30	49.92
Al (me/100g)	trace	0.07	0.03	0.06	0.05	0.05	0.05	0.06	0.06	0.04	0.05
Cl (mg/kg)	1141	779	573	927.7	573	714.7	714.7	691	738.7	821	773.23
EC (mS/cm)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.03	0.03	0.03

The way forward

The preliminary data obtained on vegetative growth and field observations indicate that some of the hybrids have very vigorous growth and may start bearing fruits after three years of planting. This is attributed to good crop management, especially irrigation during dry spells. However, at the end of this project in December 2004, the yield data were still not available because the plants were too young. It is therefore necessary that all efforts should be taken to ensure that the trials are continued with adequate funding for at least another five years in all the participating countries so that the necessary yield data could be gathered and analyzed. The Government of Tanzania has expressed its commitment to continue maintaining the trials after the project phaseout. In addition, the Government of Tanzania has also endorsed COGENT's idea of requesting CFC to consider funding a subsequent project on 'Poverty reduction in coconut growing communities' aimed at increasing the coconut farmers' income using the results of the previous project. This way, an adequate level of funding could be guaranteed to continue the trials in the participating countries.

Annex 1. Description and pictures of parent varieties used in producing the local hybrids for the coconut hybrids trials in Tanzania[1]

Pemba Red Dwarf (PRD)
by KE Mkumbo and AK Kullaya

History and description

In Tanzania, Pemba Red Dwarf (PRD), as the name suggests, was collected from Pemba Island. Its historical background and local name of 'Kitamli' suggest its introduction by the Tamil traders to East Africa. PRD could be found along the Tanzanian and Kenyan coastal area, as well as in Mozambique, Madagascar, Comoros and Mauritius.

PRD bears no bole; it has a thin stem measuring 15cm at 20cm above ground level and 20 cm at 1 m above ground level. The stem is narrower at the base than at the upper portion. Top leaves are erect and straight; peduncles and petioles are straight. Reproductive system is direct autogamy. Within a sub-type the colour is stable; differences are due to co-existence with other sub-types.

Identification

PRD palms have a close resemblance to some varieties, such as the Cameroon Red Dwarf (CRD) from West Africa, the Papua New Guinea Red Dwarf, or the King Coconut from Sri Lanka. The fruits are oval and fruit colour is golden. The bunch stalks are long, holding the fruits of all ages at the same distance from the stem. The similarity to other varieties was not realized until after the CRD had been introduced for hybrid seed production purposes. Molecular DNA studies have shown that the PRD and the CRD are closely related. In observations made in Tanzania where the two varieties are available, PRD fronds do not droop as those of CRD due to reflexed petioles. Peduncles are longer than other red or yellow Dwarfs but are shorter than those of CRD.

Yield and production

PRD produces medium-sized, oval-shaped fruits. The husk is thin and the average fruit weight is 690g. It has an oval-shaped nut which weighs about 500g. Under favourable edaphic and climatic conditions, PRD is highly precocious, coming to first bearing in 2-3 years after field planting. It produces 30-70 fruits/palm/year under rainfed conditions. It is mainly grown for its sweet and tasty liquid endosperm. The low oil and sugar content in the solid endosperm makes it not suitable for copra production. It is a very good ornamental palm. PRD is sensitive to drought and is mostly found around homesteads.

Other information

PRD is sensitive to *Pseudotheraptus wayi* and mite attack but is moderately tolerant to lethal yellowing disease (LYD). This variety has been used for production of Breeders' Test Materials for producing materials resistant to LYD and tolerant to drought mainly as seed parent with RIT, EAT and VTT (as father palms), progenies of which are under field trials.

References

E. Krain, J.A. Issa, A. Kullaya and H.C. Harries. The natural and economic history of the coconut in Zanzibar

Krain, E and J.A. Issa. 1991. Report on first observation in the Variability of Pemba Dwarf, Contribution to the Annual Report of NCDP 1990/1991, NCDP Zanzibar, Zanzibar.

[1] For the description and pictures of Renell Island Tall (RIT) and Vanuatu Tall (VTT), please refer to Annex 1 of "Coconut hybrid trials in Cote d'Ivoire" in this book, pp. 32-51.

Pemba Red Dwarf (PRD)

Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

East African Tall (EAT)

by KE Mkumbo KE, AK Kullaya and R Bourdeix

History and description

The written reference to coconut in Tanzania dates back to 60 AD. This reference has been taken as an evidence of introduction of coconut to Tanzania by Indian merchants. By 1890, Tanzania had an estimated 955 000 coconut palms. From 1888-1916, German administration strongly stimulated coconut growing by distributing seednuts and seedlings to smallholder farmers. This happened along the whole coast of Mainland Tanzania. To date, coconut palms are found not only along the Indian Ocean coastal belt but deep in the mainland too. The main coconut variety of economic importance grown in Tanzania is the East African Tall (EAT).

EAT is very heterogeneous because of allogamy. Fruits weigh 750-1450g; the colour of its fruits is variable, ranging from red to yellow, green and brown, although most EAT palms bear green or brown fruits. Fruits are generally oval-shaped with thick husk. Nuts are oblong, has a thick shell (26-37%) and with meat thickness between 47-58%. The palm normally bears a bole with very thick stem and can grow up to 100m tall. Crown shapes are variable: X, V, semi-circle or circular. Its youngest leaves are erect while older ones vary with crown shape – erect for V-shaped, reflexed petioles for circular- and X-shaped and straight for semi-circle crowns. Peduncles are long with their colour being similar to that of the fruit and petiole. Often, the stem is narrower just above the bole and progressively thicker above. EAT has numerous sub-populations. Characterization data can be found in Tanzania and Cote d'Ivoire and in COGENT's International Coconut Genetic Resources Database (CGRD).

Identification

EAT has a close resemblance to the Mozambique Tall (MZT) and probably to some other Tall varieties from the Indian Ocean Islands such as Madagascar, Comoros and Mauritius. The distinctive identity of EAT are its fruit shape and components.

Yield and production

EAT produces medium-sized, oval nuts. The average fruit weight is 1100g. First bearing comes 6-8 years after field planting. Palm yield per year range between 40-80 nuts under rainfed conditions. Higher yields can be obtained under more favourable moisture regimes. EAT is mainly grown for copra production, fresh nuts consumption and as a source of fresh vegetable oil for domestic use. The palm is drought-tolerant.

Other topics

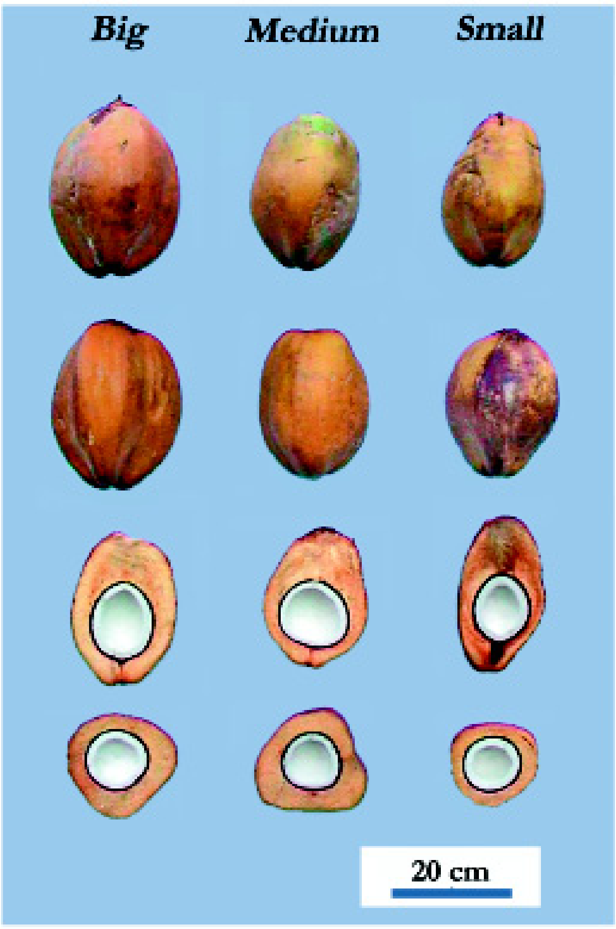
EAT is moderately tolerant to LYD but is sensitive to *P. wayi* and mite attack. It has been extensively used for search for LYD-resistant genes through production of Breeders' Test Materials.

As a predominant variety in Tanzania and East Africa, the EAT is being improved for yield and disease resistance through selection. Selected materials are then used as seed sources for distribution to farmers.

References

M. Schuiling. 1992. Final report of GTZ Plant Pathologist research on Lethal Disease, January 1980 to June 1992.

East African Tall (EAT)



Pictures courtesy of ***Dr. Roland Bourdeix****, CIRAD*

Coconut hybrid trials in Brazil

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Introduction

Coconut palm (*Cocos nucifera* L.) is considered a crop of great economic importance in Brazil. The cultivated area of about 250 000 ha countrywide generates a production of approximately 1.2 billion nuts per year (Table 1). Currently, there are about 220 000 Brazilian coconut producers cultivating farms averaging 10 ha.

Table 1. Coconut production in Brazil (1999-2003)
(*Source: IBGE – Produção Agrícola Municipal)*

	1999	2000	2001	2002	2003
Area planted to coconut (ha)	251 908	266 577	255 551	280 835	281 630
Collected area (ha)	201 116	264 311	273 338	276 598	280 382
Production (in '000 nuts)	1 206 664	1 301 411	1 420 547	1 928 236	1 985 661
Productivity (nuts per ha	4 824.42	4 923.79	5 197.03	6 971.26	7 081.98

Rationale and justification of the project

Coconut production is concentrated in the Northeast region of the country where the Tall variety predominates, mainly for production of dried kernel or copra, which is destined for household consumption or for the food industry. In the last two decades, some production areas in the other regions of Brazil, originally not devoted to coconut, started cultivating the Dwarf variety to supply the demand for coconut water.

The productivity of Tall varieties in Brazil is estimated at only 30 nuts per palm per year on average, mainly due to high deficits of rainfall, phytosanitary problems and low fertility of soils. In addition, the genetic materials used for rehabilitating old coconut plantations are of low quality, usually from segregates of natural hybrids, since genetically-improved seednuts are not readily available.

Given this current status of coconut, Brazil, along with five other African, Latin American and Caribbean countries (Benin, Cote d'Ivoire, Tanzania, Jamaica and Mexico) participated in a CFC-funded project entitled, "Multilocation trials to identify suitable hybrids and varieties for Africa, Latin America and the Caribbean", through the Brazilian Agricultural Research Corporation (Embrapa) and IPGRI/COGENT. The objective of this work was to evaluate the performance of coconut hybrids produced in Cote d'Ivoire and in the northeast region of Brazil and analyze their suitability given the different agroclimatic conditions existing in the countries involved, compared to four locally-produced hybrids. It was envisioned that the results of this project would lead to a more profitable and sustainable use of coconut hybrids to benefit the smallholder farmers.

Research methodology and results

The trial site

The trial site is located within the Itaporanga Experimental Station, which is about 0.5 ha in size. The station is located about 20 km south of Aracaju, Sergipe State at 10º 55' south latitude and 37º 03' west longitude, and is 1.5 m above sea level. The area is flat, has good drainage and ha the ideal conditions for growing coconuts.

Soil analysis

The soil type in the trial site is Ferric Podzol (FAO/UNESCO 1994) or Neossolo (Brazilian system). The soil is also classified as 'Entisol' by the American Classification System. Soil samples were collected and taken to the soil laboratory for analysis. The particle size and chemical characteristics of the soil are shown in Table 2.

Table 2. Soil characteristics of the Itaporanga Experimental Station trial site

Soil depth (cm)	Sand	Silt g kg^{-1}	Clay	OM*	pH	Al	Ca $cmol_c\ dm^{-3}$	Mg	P	K $mg\ dm^{-3}$	Na
0-20	980.0	18.0	2.0	14.0	5.4	0.00	0.64	0.26	44.7	43.4	27.6
20-40	980.0	18.0	2.0	10.0	5.5	0.20	0.22	0.42	12.2	36.3	21.9
0-100	980.0	18.0	2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**OM = Organic matter*

The soil chemical analysis as indicated in Table 3 shows very low phosphorus content; hence, 5 kg of rock phosphate was added to the soil around each plant to compensate for this deficiency. Also, to supply organic matter and nitrogen, dry cow and sheep manures were added to the soil.

Table 3. Chemical composition of the soil at Itaporanga Experimental Station

Variety and hybrids' plots	OM (%)	pH	Ca $mmol_c\ dm^{-3}$	Mg	K	Na $mg\ dm^{-3}$	P
BRT o.p.	1.7	6.5	11.5	4.9	48.7	17.9	83.2
BGD x BRT	2.0	6.8	16.3	5.9	65.7	51.4	404.2
BGD x VTT	1.7	6.3	10.0	5.3	60.3	19.2	81.1
MYD x WAT	1.7	7.0	18.5	6.0	32.6	21.8	253.1
MRD x TAG	2.0	6.8	18.3	6.9	42.3	38.6	428.0
VTT x TAG	1.8	6.9	15.5	3.9	44.4	28.3	277.6

Water level measurements were also taken weekly and the data was used to decide the schedule of watering the seedlings. To monitor the underground water, a network of wells was installed between rows as well as in the periphery of the trials.

Climatic data

The annual rainfall pattern over a 20-year period at Aracaju is shown in Figure 1. According to Koppen classification, the climate is categorized as 'Raining tropical with dry summer', with average daily temperature above 15°C. The long rainy season lasts for 5-7 months, from August to February. During the driest months, rainfall is lower than 44 mm. The average annual rainfall is 1200 mm. To obtain more detailed climatic data, an automated meteorological station was installed at the Itaporanga Experimental Station.

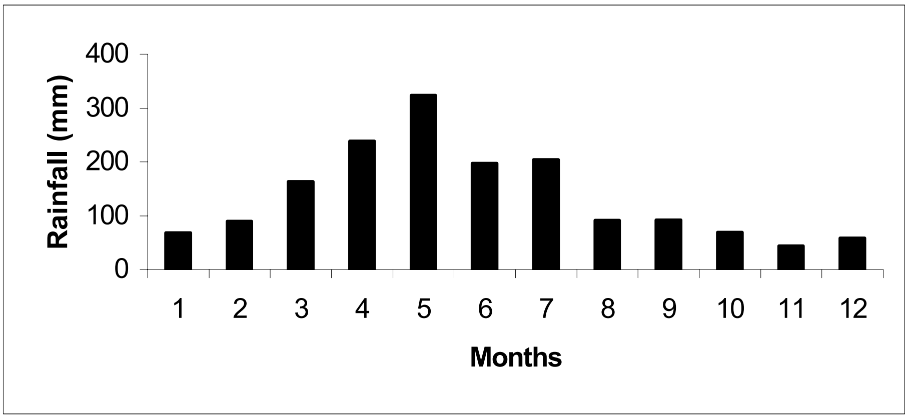

Figure 1. Annual rainfall distribution pattern at Aracaju for the last 20 years (1984-2004) *(Source: Agricultural Ministry/4th District of Meteorology)*

Table 4 shows the rainfall distribution at Itaporanga Experimental Station from September 2000 to October 2004. The average rainfall for this 5-year period was recorded at 1019 mm.

Table 4. Rainfall distribution at Itaporanga Experimental Station from 2000 to 2004 (in mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	-	-	-	-	-	-	-	-	321	6	31	50	**408**
2001	80	75	56	77	87	148	147	108	58	102	47	53	**1038**
2002	190	121	56	60	320	181	88	67	35	1	75	9	**1203**
2003	32	100	77	48	231	158	162	150	59	104	152	62	**1337**
2004	225	130	53	86	125	87	96	253	37	12	6	-	**1110**
Mean	**131**	**106**	**60**	**67**	**190**	**143**	**132**	**108**	**118**	**45**	**62**	**43**	**-**

First batch of imported and local hybrid trials

The first batch of the six imported hybrids (VTT x TAGT, SLT x TAGT, MYD x WAT, CRD x RIT, MRD x VTT, MRD x TAGT) produced in Côte d'Ivoire was air-shipped to Brazil in November 1999, while the four local hybrids: Brazil Tall 1 (BRT 1), Brazil Green Dwarf x Brazil Tall 2 (BGD x BRT 2), Brazil Green Dwarf x Vanuatu Tall (BGD x VTT), and Malayan Yellow Dwarf x Brazil Tall 1 (MYD x BRT 1) were produced in Brazil (see Annex 1 for pictures and description of parent varieties). The seednuts of the four local hybrids and the Brazil Tall (BRT) variety were produced at the Experimental Station in Betume, Neopolis, SE; at Jiqui Experimental Station, Rio Grande do Norte State; and at the Praia do Forte Farm, Bahia State. The seednuts were germinated in a nursery, under irrigation and transplanted in polybags, at Itaporanga Experimental Station where the trials were conducted.

The number of available seedlings from the first batch of seeds received from Côte d'Ivoire was insufficient to carry out the trials as originally planned. In order to overcome this problem, a discussion with Dr Roland Bourdeix of CIRAD and with Dr Maria de Lourdes da Silva Leal, a statistician from EMBRAPA, was carried out and, subsequently, two experiments were installed in a triangular planting pattern at 8.5 m in a randomized complete block design.

The first batch of seedlings, consisting of 150 seednuts each, was used as a general observation trial and divided into two trials as shown below.

a. Trial 1 - Six treatments (three hybrids from Côte d'Ivoire: MYD x WAT, MRD x TAGT and VTT x TAGT; two local hybrids: BGD x BRT and BGD x VTT; and one open-pollinated variety (BRT) with five replications and seven palms per plot;

b. Trial 2 - Ten treatments (six hybrids from Côte d'Ivoire: MYD x WAT, CRD x RIT, MRD x VTT, MRD x TAGT, VTT x TAGT and SLT x TAGT; three local hybrids: BGD x BRT, MYD X BRT and BGD x VTT; and one open-pollinated variety (BRT) from Praia do Forte with four replications and five palms per plot.

The trials were planted in September 2000. As the planting time took place at the beginning of the dry season, irrigation was carried out. In 2000-2001, 40% of the seedlings died due to dry bud rot disease and were also attacked by *Coraliomella brunea*, which was controlled with natural insecticides consisting of oil of Neem leaf extract at 5%.

Table 5 shows the status of the first batch of seedlings. The CRD x RIT and the MYD x BRT hybrids had the lowest number of germinated seednuts while the MYD x WAT hybrid and the variety BRT had the highest number of surviving seedlings. Currently, the seedlings are being maintained in the field and are growing very well.

Table 5. Available seedlings of the six imported and three local hybrids

Hybrids/Variety	Number of seednuts		Percentage germination	Surviving seedlings	
	Sown	Germinated		No.	Percentage
A. Imported hybrids					
VTT x TAGT	144	62	43	60	97
SLT x TAGT	150	46	31	41	89
MYD x WAT	159	83	52	82	99
CRD x RIT	156	22	14	21	95
MRD x VTT	155	26	17	23	88
MRD x TAGT	156	73	47	72	98
B. Local hybrids and variety					
BGD x VTT*	130	78	60	78	100
BGD x BRT**	160	140	88	130	93
MYD x BRT*	40	25	63	25	100
BRT (o.p.)	205	157	77	140	89

* *Produced in Experimental Field of Betume, Embrapa, Neopolis, SE*

** *Obtained from commercial production of the Experimental Station of EMPARN, State of Rio Grande do Norte*

** *Collected from original population in Praia do Forte, State of Bahia*

Vegetative data of the first batch of introduced and local hybrid trials

The number of leaves of the entries in the first trial is shown in Table 6. Except for VTT x TAG, the leaf production was higher for all the hybrids than the local variety BRT at all times. This means that all the hybrids were superior to the local variety in terms of initial vegetative growth.

Table 7. Vegetative data (average leaf production) of the palms in Trial 1

Hybrids	Average number of leaves produced			
	December 2002	June 2003	October 2003	June 2004
BRT (o.p.)	8.6	9.2	11.2	13.6
BGD x BRT	9.0	9.6	11.8	16.6
MYD x BRT	13.8	14.2	14.0	20.4
BGD x VTT	13.0	13.7	16.2	17.5
MYD x WAT	12.2	13.0	16.2	19.8
CRD x RIT	10.4	11.2	14.8	19.9
MRD x VTT	11.4	12.2	14.4	15.6
MRD x TAGT	11.2	12.0	14.0	18.5
VTT x TAG	9.4	10.1	12.0	13.6
SLT x TAG	11.4	12.3	14.6	15.5
Mean	**11.0**	**11.7**	**13.9**	**19.93**

Leaf samples from the first batch of seedlings were collected in December 2002. The result of the chemical analysis is shown in Table 7. Nutrients such as nitrogen, phosphorus, potassium, magnesium, sulfur and boron content were below the critical level. Appropriate fertilizers were thus applied based on the chemical characteristics of the leaf samples.

Table 7. Macro- and micronutrient contents of leaf samples from the first batch of seedlings

Sample Identification	Macronutrient								Micronutrient				
	N	P	K	Na	Ca	Mg	S	Cl	Mn	Zn	Fe	Cu	B
	g kg^{-1}												
Trial I - Strip I	1.55	0.119	1.491	0.223	0.234	0.208	0.099	0.714	93.871	12.935	80.272	6.360	14.267
Trial I - Strip II	1.70	0.145	1.409	0.189	0.270	0.253	0.131	0.638	104.151	13.924	54.543	6.809	13.446
Trial II - Rep I	1.67	0.129	1.341	0.149	0.348	0.304	0.088	0.703	48.918	11.453	60.895	5.436	11.472
Trial II- Rep II	1.49	0.122	1.462	0.260	0.232	0.218	0.114	0.710	109.592	13.413	60.441	5.907	15.074
Trial II - Rep III	1.51	0.115	1.565	0.250	0.213	0.205	0.135	0.671	85.718	13.062	47.593	5.915	15.094
Trial II - Rep IV	1.45	0.126	1.387	0.232	0.237	0.219	0.146	0.709	87.558	11.560	75.437	6.734	18.740

As for reproductive (flowering and fruiting) data, four hybrids in Trial 1 (BGD x BRT, BGD x VTT, MYD x WAT and MRD x TAGT) started to flower and bear fruits three years after planting (Table 8). On the other hand, the BRT and VTT x TAG neither flowered nor formed fruits during same period. It is interesting to note that although the MRD x TAGT cross was the most precocious in terms of flowering (17 flowered out of 33 planted, or 51.52%) among the hybrids tested, it was the local hybrid BGD x BRT that had the best performance in terms of nut development (91.67%). Although some differences in precocity were noted, these initial reproductive data support the findings that hybrids do flower and/or bear fruits (usually on the third year) way earlier than the traditional varieties, which take seven years to flower on average, given the necessary inputs and ideal conditions.

Table 8. Reproductive (flowering and fruiting) data of the palms in Trial 1

Variety/Hybrids	No. of palms planted	Flowering palms		Fruiting palms	
		No.	%	No.	% based on flowering palms
BRT o.p.	35	0	0	0	0
BGD x BRT	35	12	34.28	11	91.67
BGD x VTT	35	6	17.14	4	66.67
MYD x WAT	34	7	20.59	5	71.43
MRD x TAGT	33	17	51.52	14	82.35
VTT x TAGT	35	0	0	0	0
TOTAL	**207**	**42**	**20.29**	**34**	**80.95**

Second batch of imported and local hybrid trials

For the second batch of the trials, a total of 1200 seednuts were shipped by Côte d'Ivoire to Brazil. Upon arrival, these were kept at Quarantine/Cenargen and were released in November 2002 (Table 9). Due to delayed quarantine release, the germination was low and the seedlings received were not enough to install the experiment scheduled for the second trial; hence, the second batch of seedlings was not planted as a trial. Instead, some of the good quality seedlings were maintained at Itaporanga Experimental Station and were used to add to the number of seedlings of the third batch and set up as the second trial (also referred to as the third batch).

Table 9. Second batch of seeds and seedlings received from Côte d'Ivoire

Hybrids	Number of seednuts shipped from Côte d'Ivoire	Received from quarantine in November 2002		Number of surviving seedlings as of August 2003
		Seednuts	Seedlings	
MYD x WAT	200	10	54	46
CRD x RIT	200	4	35	32
MRD x VTT	200	10	120	92
MRD x TAGT	200	11	131	102
VTT x TAG	200	6	18	16
SLT x TAG	200	4	49	48
TOTAL	**1200**	**45**	**407**	**336**

Vegetative data of the second batch of introduced and local hybrid trials

Table 10 shows the chemical analysis of the leaf samples from the second batch of seedlings which were collected in December 2002. The results indicated that nutrients such as nitrogen, phosphorus, potassium, magnesium, sulfur and boron were below the critical level. Appropriate fertilizers were thus applied to augment the deficiencies based on the chemical analysis of the leaf samples.

Table 10. Macronutrient and micronutrient contents of leaf samples from the second batch of seedlings

Sample number	Macronutrient								Micronutrient				
	N	P	K	Na	Ca	Mg	S	Cl	Mn	Zn	Fe	Cu	B
	g kg^{-1}												
3	16.7	1.29	13.41	1.49	3.48	3.04	0.88	7.03	48.9	11.4	60.9	5.4	11.5
4	14.9	1.22	14.62	2.60	2.32	2.18	1.14	7.10	109.6	13.4	60.4	5.9	15.1
5	15.1	1.15	15.65	2.50	2.13	2.05	1.35	6.71	85.7	13.1	47.9	5.9	15.1
6	14.5	1.26	13.87	2.32	2.37	2.19	1.46	7.09	87.5	11.6	75.4	6.7	18.7

The reproductive (flowering and fruiting) data gathered from the second batch of seedlings in Trial 2 (Table 11) showed that most of the hybrids started to flower in February 2003, which was only two years and five months after planting. The entire Dwarf x Tall crosses and one Tall x Tall hybrid reached their reproductive phase within this period. As in Trial 1, the MRD x TAGT (Figure 2) cross was the most precocious (12 palms or 48% out of the 25 planted flowered; and from those that flowered, all or 100%, formed nuts).

Table 11. Reproductive (flowering and fruiting) data of the palms in Trial 2

Variety/Hybrids	No. of seedlings planted	Flowering palms		Fruiting palms	
		No.	% from planted	No.	% of flowering palms
BRT o.p.	25	0	0	0	0
BGD x BRT	25	4	16	3	75
MYD x BRT	25	7	28	2	28.57
BGD x VTT	25	4	16	4	100
MYD x WAT	25	11	44	7	63.64
CRD x RIT	25	4	16	4	100
MRD x VTT	25	7	28	6	85.71
MRD x TAGT	25	12	48	12	100
VTT x TAGT	25	0	0	0	0
SLT x TAGT	25	2	8	0	0
TOTAL	**250**	**51**	**20.4**	**38**	**74.51**

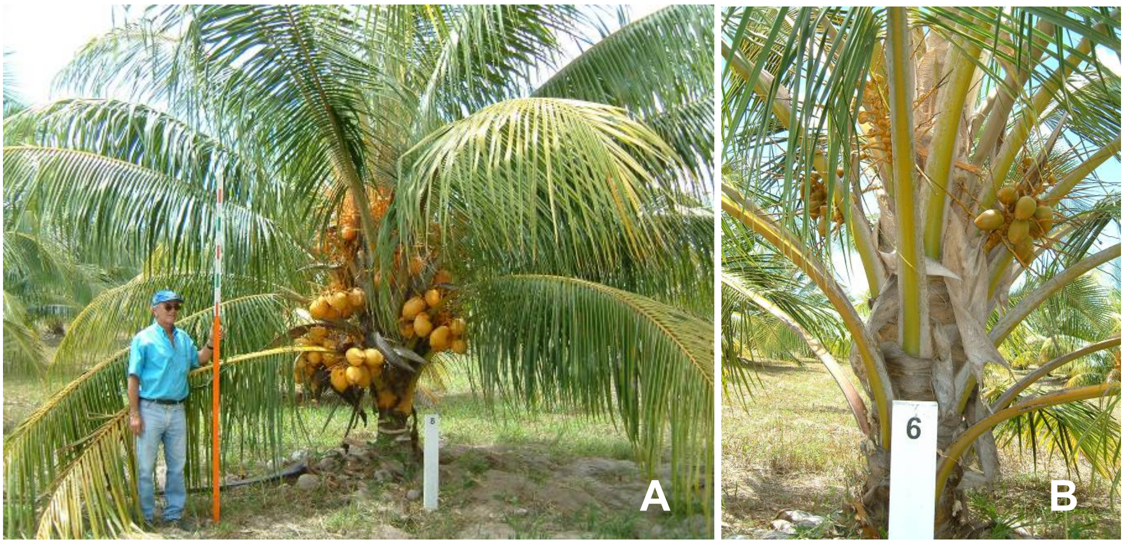

Figure 2. Pictures of some of the Trial 2 hybrids: (A) MRD x TAGT; and (B) CRD x RIT

Third batch of imported and local hybrid trials

A total of 1620 seednuts were received from Côte d'Ivoire of which 609 germinated during the period when the seednuts were in quarantine (Table 12). The seedlings of the third batch were transferred from Quarantine/Cenargen, Brasilia, to Itaporanga Experimental Station in August 2003.

Table 12. Number of seednuts received from Côte d'Ivoire for the third batch of trials

Hybrids	No. of seednuts shipped from Côte d'Ivoire	Seedlings available as of August 2003
MYD x WAT	300	167
CRD x RIT	300	146
MRD x VTT	300	143
MRD x TAGT	300	55
VTT x TAG	210	54
SLT x TAG	210	44
TOTAL	**1620**	**609**

Trial 3 was planted in September 2003 using a triangular pattern at 9.0 m distance between plants in a randomized complete block design with four replications and five plants per plot. The trial consisted of the following treatments:

- Six hybrids from Côte d'Ivoire (MYD x WAT, CRD x RIT,MRD x VTT, MRD x TAGT, VTT x TAG and SLT x TAG);
- Three local hybrids (BGD x BRT, MYD X BRT and BGD x VTT); and
- One variety (BRT o.p.).

Before each seedling was planted, dry coconut husk and 800 g of phosphorus phosphate were put into each planting hole. As planting took place at the beginning of the dry season, irrigation was also carried out. Eventually, 61 plants died due to dry bud rot disease (Table 13) but were replaced by the remaining seedlings from the second batch.