

COCONUT RESEARCH INSTITUTE - REPORT FOR 2006

COCONUT RESEARCH BOARD

**COCONUT RESEARCH INSTITUTE
OF SRI LANKA**

REPORT FOR 2006

COCONUT RESEARCH BOARD



REPORT OF THE COCONUT RESEARCH INSTITUTE FOR 2006

Editorial Committee

C Jayasekara, Ph D (Qld)
J M D T Everard, M Sc (Jayawardenapura)
P A Henry Nimal Appuhamy, M Sc (Reading)
E M T Bandaranayake, M Sc (Peradeniya)

THE MEMBERS OF THE BOARD

The members of the board as at 31st December 2006

Dr D B T Wijeratne	-	Chairman
Dr (Mrs) C Jayasekara	-	Director, CRI/Member
Mr. M H J P Fernando	-	Member
Mr N Mithraratne	-	Member
Mr J V R Dias	-	Member
Mr R A Ariyawansa	-	Member
Dr J D H Wijewardana	-	Member
Mr W J L S Wijayaweera	-	Member
Mr Jagath Wellawatta	-	Member
Mrs J M S D Rathnayake	-	Member, Treasury Representative
Mr D J U P Purasinghe	-	Member
Mr P G Dassanayake	-	Member
Dr Newton Peiris	-	Advisor/MCD
Dr H A J Gunathilaka	-	Member

COMMITTEES OF THE COCONUT RESEARCH BOARD
as at 31st December 2006

1. Research Committees

Dr D B T Wijeratne	Chairman, CRB
Dr (Mrs) C Jayasekara	Director, CRI
Mr J M D T Everard	DD (R)/CRI
Dr U Pethiyagoda	Member
Dr D T Wettasinghe	Member
Dr Ray Wijewardene	Member
Dr Sunil Jayasekara	Member
Mr Parakrama Jayathilaka	Member
Dr Shantha Ramanayake	Member
Dr Anil Jayasekara	Member
Prof. Thilak Attanayake	Member
Dr R A Ariyawansa	Member
Dr Jayanthi Edirisinghe	Member
Prof. Rohan Rajapaksha	Member
Dr Chandra Jayasinghe,	Member
Dr Manel Dassanayake	Member
Dr Padmini Gunasekara	Member
Mr Denzil Aponso	Member
Mr B Jayasuriya	Member
Dr D S P Kuruppuarachchi	Member
Mr N C Kumarasinghe	Member
Dr Janaki Gooneratne	Member

2. The Audit and Management Committee

Mrs J M S D Rathnayake	Member
Mr W J L S Wijayaweera	Member
Dr J D H Wijewardana	Member
Mr J G Weerasinghe	Superintendent of Audit, Auditor General's Department

3. Estates Committee

Mr J M D T Everard	(Chairperson)
Dr. N A Tennakoon	
Dr (Mrs) C K Bandaranayake	
Dr N P A D Nainanarake	
Mr. I M S K Idirisinghe	
Mr I R Wickramanaha	
Mr Parakrama Liyanagama	(Ex Manager Estates)

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COCONUT RESEARCH INSTITUTE OF SRI LANKA

THE STAFF

(As at 31st December 2006)

DIRECTORATE

Director : Mrs. C Jayasekara, B.Sc. (Botany), Ph.D. (Qld)

Deputy Director (Research): J M D T Everard, B.Sc., M.Sc. (England), M.Sc. (Sri J'pura)

Deputy Director (Administration & Finance): E P Gunapala, A.P.F.A., B.Com (Sp)
Diploma in Accountancy

RESEARCH DIVISIONS

Agronomy Division

Head

H A J Gunathilake, B.Sc. (Agric), Ph.D. (Wales)

Senior Agronomist

R P B S H S Senaratne, B.Sc. (Agric),
M.Sc. (Agric)

Agronomist

Miss S C Somasiri, B.Sc. (Agric), M.Sc.

Agricultural Economist

Mrs. K V N N Jayalath, B.Sc. (Agric)

Assistant Research Officer

B A S Manjula, B.Sc. (Agric)

Senior Technical Officers

H A Abeysoma

M J I Costa

R Marasinghe, B.Sc. (Agric),
M.Sc (Animal Production System)

Mrs. K C P Perera, B.Sc. (Sci)

Senior Lab/Field Assistants

E M Gunaratne Banda

M D V Saparamadu

W S M A Fernando

H B Perera

K D D Appuhamy

R A Swarnathilake

Lab/Field Assistants

W R O Fernando

W P Fernando

Agricultural Economics Division

Officer-in-Charge

I M S K Idirisinghe, B.Sc. (Agric), M.Sc. (Peradeniya)

Agronomist

Miss P M E K Pathiraja, B.Sc.(Agric)

Assistant Research Officer

A W A D R Abeyasekara, B.Sc.(Agric), Post G. Dip (Econ)

Senior Technical Officer

S D J N Subasinghe, Dip. (Agric.)

Genetics & Plant Breeding Division

Head

A A F L K Perera, B.Sc. (Agric), Ph.D. (Dundee)

Senior Geneticist/Plant Breeder

Miss S A C N Perera, B.Sc. (Agric),
Ph.D. (Birmingham)

Geneticists/Plant Breeders

M G M K Meegahakumbura, B.Sc. (Agric),
M.Sc.(Bio)

Miss H D M A C Dissanayake, B.Sc.(Agric)

Seed & Seedling Production & Certification Officer

L M S R Jayathilake, B.Sc.(Agric),
M.Sc.(Agric)

Seed Production & Certification Assistants

P G R S Premathilake, B.Sc.(Agric)

R I B C T Herath, B.Sc.(Agric), M.Sc.

M N Nadeeranga, B.Sc.(Agric)

R C M Wijyaratne, B.Sc.(Agric)

L J Saman, B.Sc.(Agric)

A S Jayasundara, B.Sc.(Agric)

Senior Technical Officers

Mrs. W B M S S Fernando

M H L Padmasiri

G K Ekanayake, B.Sc. (Sci)

H M N B Herath

R B Attanayake, Dip. In Plantation

S A S Chandrasiri

Technical Assistant

A A Fernando

Senior Clerk/Typist

Mrs. I N Jayawardena

Senior Lab Field Assistants

U V M Fernando

M A Hemachandra

P A D M Appuhamy

Lab & Field Assistant

Mrs. P J M Fernando

Soils & Plant Nutrition Division

Head

N A Tennakoon, B.Sc(Agric), M.Phil(Kelaniya), Ph.D.(Aberdeen), M I Biol

Senior Soil Scientist

Mrs. W C Fernando, B.Sc(Sci), Ph.D(Japan)

Soil Scientists

Mrs. D M D I Wijebandara, B.Sc.(Sci)

M.Phil(Peradeniya), M I Biol**

Mrs. H M I K Herath, B.Sc.(Agric),

M.Sc.(Soil Management)

Miss A K F Nadheesha, B.Sc.(Chemistry),

M.Sc. (Food Sci. & Technology)

Assistant Research Officer

L R M C Liyanage, B.Sc.(Agric)

Miss D Paramasivam, B.Sc

Senior Technical Officers

Mrs. S Sabharatnam, NDS

Mrs. N H R M De Silva, B.Sc.(Sci)

U S S Perera

A H Norman

D P Panditharatne

E M A T Banda

Mrs. C P A Kurudukumbura, B.Sc.(Agric)

Mrs. S D H Bandara, B.Sc.(Sci)

Technical Officers

K P A Pathirana, Dip. (Agric)

B S V J Perera, Dip. (Agric)

Mrs. H L A Padmini, Dip. (Agric)

Technical Assistant

M R D Perera, B.Sc.(Sci) ***

Senior Stenographer

Mrs. H M A Herath

Senior Lab/Field Assistant

K L Ranasinghe

K R E M Fernando

F H A J R Silva

W Gunasena

Lab/Field Assistant

K J S Perera

Crop Protection Division

Head

Mrs. L C P Fernando, B.Sc.(Agric), Ph.D.(Qld)

Senior Entomologist

I R Wickramananda, B.Sc.(Agric),
M.Phil (Aberdeen)

Senior Plant Pathologist

H T R Wijesekara, B.Sc.(Agric),
Ph.D.(Delhi)

Entomologist

Mrs. N S Aratchige, B.Sc.(Agric)

Assistant Research Officer

A D N T Kumara, B.Sc.(Agric),
M.Sc.(Crop Protection)
Mrs. N I Suwandarane, B.Sc.(Agric)

Senior Technical Officers

K A S Chandrasiri
K F G Perera
Mrs. D C L Hapuarachchi
Miss P H A P Siriwardena, B.Sc.(Agric)
P H P R De Silva, B.Sc.(Agric)

Senior Clerk

Mrs. A A De Zoysa

Senior Lab/Field Assistant

W W F N Fernando
N G Premasiri

Biometry Division

Head

T S G Peiris, B.Sc (Sci), M.Sc (Stat. Canterbury,NZ), F.R.S (UK), Ph.D.(Colombo)

Biometrician

Mrs. K P Waidyaratne, B.Sc.(Agric)

Senior Technical Officers

J D J S Kularatne, B.Sc.(Sci)

Technical Officer

S S Rajapakse, Dip.(Agric)

Technical Assistant

W A S Wickramarachchi

Senior Clerk/Typist

Mrs. U I Abeysinghe

Senior Lab/Field Assistants

W B P Fernando
W E R C Fernando
W K M K Herath
W M L G Fernando

Tissue Culture Division

Head

Mrs. L K Weerakoon, B.Sc.(Botany), M.Sc.(Illinois State), Ph.D.(Illinois State)

Principal Botanist

Mrs. W N I S C Fernando, B.Sc.(Russia),
M.Phil(UK), Ph.D.(Colombo)

Senior Technical Officer

E S Santha

Senior Botanists

Mrs. V R M Vidanaarachchi, B.Sc.(Agric),
Ph.D.(Kagoshima)

Botanists

Mrs. P I P Perera, B.Sc.(Agric)

Mrs. H D D Bandupriya, B.Sc.(Botany)**

Technical Officers

K P I E Ambagala, Dip.(Agric)

Miss T R Gunathilake

Plant Physiology Division

Head

Mrs. C S Ranasinghe, B.Sc., Ph.D.(Sussex) ****

Senior Plant Physiologist

N P A D Nainanayake, B.Sc.(Sci),
M.Phil (Peradeniya),
Ph.D.(Essex)

Senior Technical Officers

Mrs. W P K K Fernando, B.Sc.(Sci)
R D N Premasiri
L R S Silva

Plant Physiologists

Mrs. M A D W S Madurapperuma,
B.Sc.(Agric), M.Phil(Peradeniya)
B H C Mendis, B.Sc.(Botany)

Technical Assistant

Mrs. H P I N M Gunawardena, B.Sc

Senior Lab/Field Assistant

A Jayathilake

Coconut Processing Research Division

Officer-in-Charge

J M M N Marikkara, B.Sc(Chem), Ph.D.(Putra Malaysia)

Senior Food Technologist

Mrs. L L W C Yalgama, B.Sc(Chem)
M.Sc(India)

Miss J M M A Jayasundara,
M.Sc(Analytical Chemistry) (Peradeniya)
K D P P Gunathilake, B.Sc(Agri),
M.Sc(Peradeniya)

Senior Technical Officers

G R A Dharmasena, B.Sc(Sci)

Technical Assistant

A R Kulatunga, Dip.(Agri)
A R A N Kumara

Assistant Chemical Engineer

J R K Asanka, B.Sc(Engineering)

Assistant Mechanical Engineer

Mrs. J A K M Fernando, B.Sc(Engineering)

Technology Transfer Division

Head

P A H N Appuhamy, B.Sc.(Agric), M.Sc.(Reading)

Extension Officers

A M A P G Gunawardena, B.Sc.(Agric)
M.Sc. (Agric.Extension)
C S Herath, B.Sc.(Agric),
M.Sc.(Peradeniya)

Senior Printing Machine Operator

W G L Rodrigo

Senior Clerk/Typist

R A L C Fernando

Assistant Extension Officers

Mrs. H D N H Fonseka, B.Sc(Agri),
M.Sc.(Peradeniya)
J K J P Jayawardena, B.Sc.(Agric)
A R U Ratnasekara, B.Sc.(Agric)
E M T Bandaranayake, B.Sc.(Agric)
M.Sc.(Peradeniya)

Senior Lab & Field Assistant

H P Ashoka Kumara

Library Service Division

Acting Librarian

J M D T Everard, B.Sc., M.Sc.(England), M.Sc.(Sri J'pura)

Assistant Librarian

Mrs. P D U C Dharmapala, (FELE), BLE

Senior Clerk/Typist

Mrs. S N Gunathilake

Administration

Deputy Director (Administration & Finance)

E P Gunapala, A.P.F.A., B.Com (Sp), Diploma in Accountancy

Establishment Unit

Administrative Officer

Miss H D Mangalika, B.A, LLB

Administrative Assistants

Mrs. P C A Fernando
A I F Fernando
A S Nanayakkara

Stenographer (English)

Mrs. M M S P Fernando

Senior Supplies Assistant

W F T Fernando

Supplies Officer

P P Fernando, B.A.,
Dip (Purchasing & Material Management)

Senior Clerk/Typists

Mrs. A R S Hettiarachchi
Mrs. W S R Fernando
Mrs. K P S Jayathilake
Mrs. M G Karunawathie
Y H Wijesena
M A D M F Appuhamy

Secretary to the Chairman

Mrs. S Z Suhair

Chief Clerk

B M D Bandara

Clerk/Typists

Senior Stenographers (English)

N M H Wijewardena

Mrs. M P Premaratne
Mrs. H M W S Athauda

Internal Audit Unit

Internal Auditor

E M Gnanaratne, B.Sc.(Business Administration), (Licentiate) Chartered Accountants

Senior Book Keeper

B M Jayathilake Banda

Senior Typist (English)

Mrs. W J M D M A Fernando

Senior Internal Audit Clerk

Mrs. M M J R Fernando

Accounts Unit

Accountant

R M U Chandranath, B.Sc.Management(Public), Chartered Accountant Intermediate Exam

Senior Book Keepers

N M R Sarathchandra, B.Com
R D Sumanasiri, HND (Accountancy)
Chartered Preliminary Exam
S M Sirisoma

Senior Accounts Clerks

W C P C Fernando
Mrs. A S M S Abeywickrama

Accounts Clerk

Senior Shroff

M C H N Fernando, BLE

Mrs. W A N K Wijesinghe
D J M Leelaratne

Senior Store Keeper

M B U Wijetunga

Senior Clerk/Typists

Mrs. C M B I Salwatura
Mrs. A A N P Kanthi

Senior Audit Clerk

R M U Attanayake

Engineering Unit

Resident Engineer

K N A S Perera, NDT(Mech-Automobile Engi)

Works Superintendent

A L D K Amarasinghe, N.Dip (Eng.Science)

Foreman (Building)

J M P K Jayasekara***

Foreman (Mechanical)

R Vithanage

Senior Draughtperson

Mrs. R M S Ratnayake

Senior Clerk/Typist

N R Ayagama

Clerk/Typists

K T G N W Perera
M Somasiri

Senior Motor Mechanic

R M S G Ratnayake

Senior Mason

W M Dhanapala

Senior Carpenter

A A K Amarasinghe

Linesman

R S P Jayamanna

Estates Management Unit

Manager (Estates)

K L N Pradeepa, B.Sc.(Agric)

Experimental Officer

G M R Karunasekara, B.Sc.(Sci)

Assistant Livestock Officer

H W A S Senaratne, B.Sc.(Agric)
M.Sc.(NRM)

Senior Clerk/Typists

W P R R Fernando
W A L R Fernando

Bandirippuwa Main Research Centre

Superintendent

I A N Hemasiri

Assistant Superintendent

H B S Herath, B.Sc.(Agric)

Field Officer

G P N Chandrasiri

Senior Supervisor

M P W Fernando

A G B G Silva

A A Sirinimal

Clerk/Typist

J K C W N Perera

Rathmalagara Research Centre

Superintendent

G B A Wijesekara

Senior Supervisor

T M Keerthirane

Ambakelle Genetic Resource Centre

Superintendent

W M U Ratnayake, Dip. in Plantation Management

Assistant Superintendent

V H E Somasiri, B.Sc.(Agric)

Senior Supervisors

A Sugathadasa

Supervisors

M A S Fernando

Senior Clerk/Typist

J A R Reginold

Lab & Field Assistant

H A P B Fernando

Maduruoya Genetic Resource Centre

Assistant Superintendent

D M I S K Dewameththa, B.Sc.(Agric)

Supervisors

W M D R Wijesinghe

Middeniya Research Centre

Assistant Superintendent

K Liyanaarachchi, B.Sc.(Agric)

Dunkannawa Research Centre

Officer-in-Charge

N Gamage

Superintendent

D P S K Hettiarachchi, Dip.(Agric. & EM)

Walpita Research Centre

Officer-in-Charge

W A H Upali

Poththukulama Research Centre

Officer-in-Charge

D L J Neththasinghe

Clerk/Typis

D M Jayawardena

Makandura Genetic Resource Centre

Superintendent

A N Ekneligoda

Assistant Superintendent

H W A N Nandakumara, B.Sc.(Agric)

Pallama Genetics Resource Centre

Assistant Superintendent

T M P A K Thilakaratne, B.Sc(Agri)

Senior Supervisor

W W A P R Fernando

Clerk/Typist

H M Podiratne

-
- ** On Study Leave
 - *** On overseas No-pay Leave
 - **** Sabbatical Leave

THE COCONUT RESEARCH INSTITUTE LUNUWILA

The Board and Institute

The Coconut Research Institute was founded in 1929 as the Coconut Research Scheme under the Coconut Research Ordinance No. 24 of 1928. The scheme established its head quarters at Bandirippuwa Estate, Lunuwila with three Technical Divisions namely Genetics, Chemistry and Soil Chemistry. Following the enactment of the Coconut Research Act No. 37 in 1950, it was renamed as the Coconut Research Institute of Ceylon. Under the Coconut Development Act, No. 46 promulgated in 1971, the Coconut Research Board was set up in 1972 to function as the Board of Management of the Coconut Research Institute.

Mission of the CRI

Our Mission is through Innovative Research and Development:

- Increase productivity and profitability of coconut
- Develop appropriate technologies to increase income from coconut lands through intercropping and animal husbandry on sustainable basis
- Provide eco-friendly appropriate technologies for integrated management of pests and diseases
- Develop new products and to improve quality, value and marketability of traditional products by generating cost effective technologies and transferring them to end-users, by employing a qualified and dedicated team of Scientists.

Functions of the Institute

As given in the Coconut Development Act No. 46 of 1971, statutory functions of the Coconut Research Board are:

1. The conducting and furthering of scientific research in respect of the growth and cultivation of coconut palms. The growing of other crops and engagement in animal husbandry in coconut plantations and the prevention and cure of diseases and pests.
2. The establishment and maintenance of Research Institutes, Experimental Stations and Nurseries.
3. The conducting and furthering of scientific research in connection with the processing and utilization of coconut products.
4. The establishment and maintenance of pilot plants for the processing of coconut products and fabrication of experimental processing equipment.
5. The training of advisory and extension workers to assist the coconut industry.
6. The guiding and advising of the coconut industry on all matters of technical nature.

The Coconut Research Board

The governing body of the Institute is the Coconut Research Board. In terms of the Coconut Development Act, the Board shall consist of 07 members, appointed by the Minister in-Charge. One member is appointed as the Chairman of the Board. The members hold office for 03 years and are eligible for reappointment.

The members of the Board and their attendance record up to December 2007 are given below:

Dr D B T Wijeratne,	Chairman
Dr M H J P Fernando,	Member
Mr N Mithraratne,	Member
Mr J V R Dias,	Member
Mr R A Ariyawansa,	Member
Dr J D H Wijewardana,	Member
Mr W J L S Wijayaweera,	Member
Mr Jagath Wellawatta,	Member
Mrs J M S D Rathnayake,	Member
	(Treasury Representative)
Mr D J U P Purasinghe,	Member
Mr P G Dassanayake,	Member
Dr Newton Peiris,	Advisor/MCD
Dr H A J Gunathilaka,	Member
Dr (Mrs) C Jayasekara,	Director CRI/Member

The new Board was appointed in March 2006 after the election.

Dr Newton Peiris, Advisor, Ministry of Coconut Development was appointed to the Board in May 2006.

Mr R A Ariyawansa passed-away in October 2006.

Mr P G Dassanayake was appointed to the Board in December 2006.

The Research Committee

The members of the Research Committee and their attendance are given below:

Dr D B T Wijeratne,	Chairman, CRB
Dr (Mrs) C Jayasekara,	Director, CRI
Mr J M D T Everard,	DD (R)/CRI
Dr U Pethiyagoda,	Member
Dr D T Wettasinghe,	Member
Dr Ray Wijewardene,	Member
Dr Sunil Jayasekara,	Member
Mr Parakrama Jayathilaka,	Member

Dr Shantha Ramanayake,	Member
Dr Anil Jayasekara,	Member
Prof. Thilak Attanayake,	Member
Dr R A Ariyawansa,	Member
Dr Jayanthi Edirisinghe,	Member
Prof. Rohan Rajapaksha,	Member
Dr Chandra Jayasinghe,	Member
Dr Manel Dassanayake,	Member
Dr Padmini Gunasekara,	Member
Mr Denzil Aponso,	Member
Mr B Jayasuriya,	Member
Dr D S P Kurupparachchi,	Member
Mr N C Kumarasinghe,	Member
Dr Janaki Gooneratne,	Member

The Audit and Management Committee

The Committee comprised of three Board Members and the Director, CRI, chaired by the Member/Treasury Representative and the attendance for the year are given below:

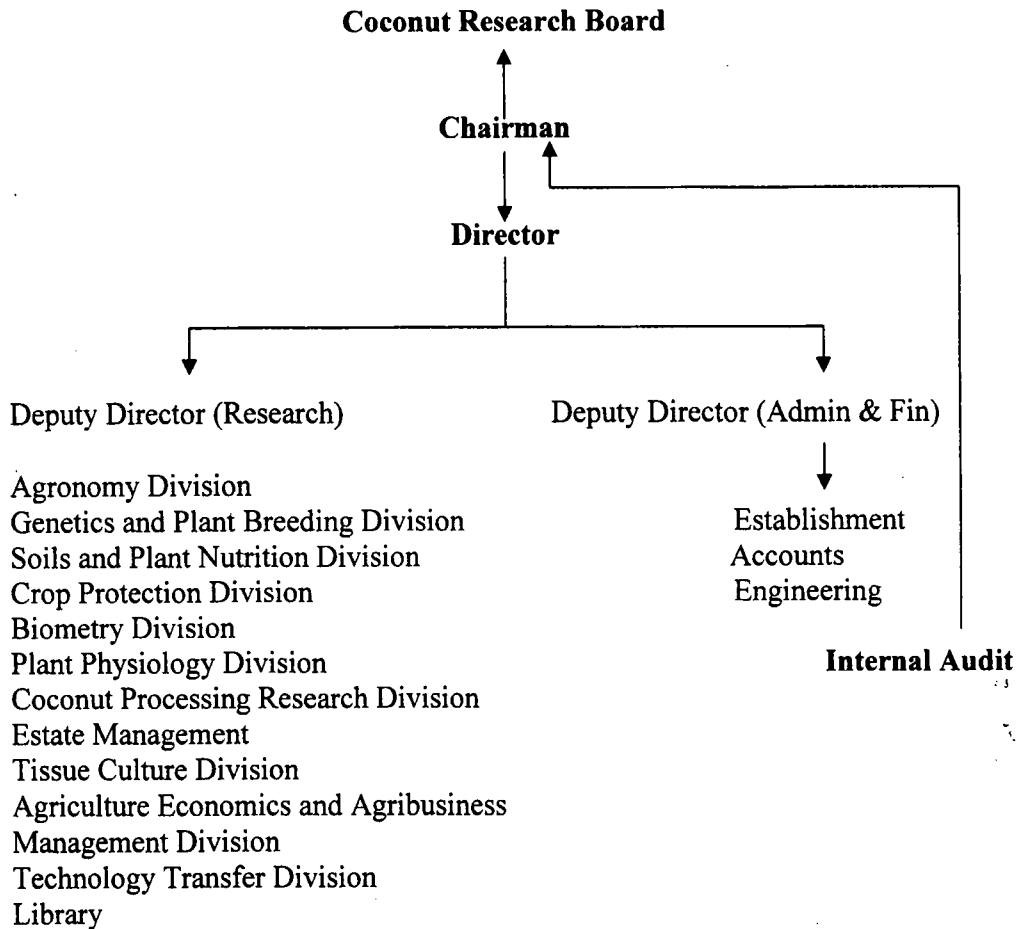
Mrs J M S D Rathnayake,	Member
Mr W J L S Wijayaweera,	Member
Dr J D H Wijewardana,	Member
Mr J G Weerasinghe,	Superintendent of Audit, Auditor General's Department
Dr (Mrs) C Jayasekara,	Director/CRI
Mr E P Gunapala,	DD (A&F)/CRI
Mr E M Gnanaratna,	Internal Auditor

The Committee held four meetings for the year.

Management

The Director who is responsible for the implementation of all policies and programs lay down by the Board and the direction and supervision of all research and administrative functions of the Institute.

Deputy Director (Research) and Deputy Director (Administration and Finance) directly supervise the Research and Service Units of the Institute respectively as given below:



The Internal Auditor is directly responsible to the Chairman.

**REVIEW OF THE DIRECTOR
COCONUT RESEARCH INSTITUTE
C Jayasekara, Ph D (QLD)**

1. GENERAL

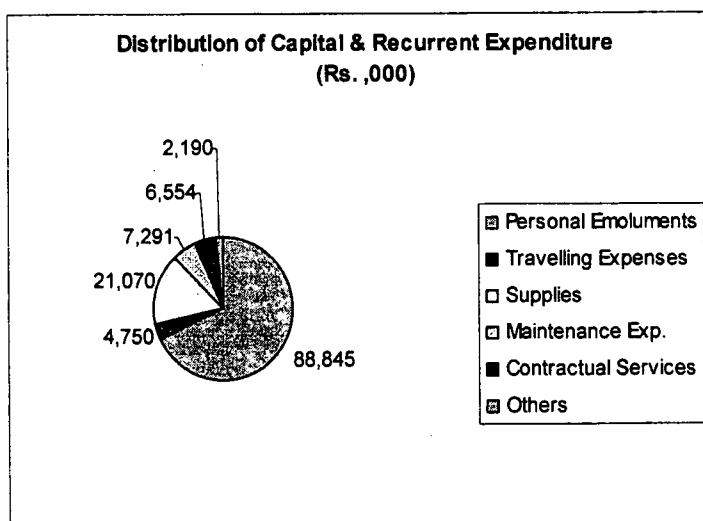
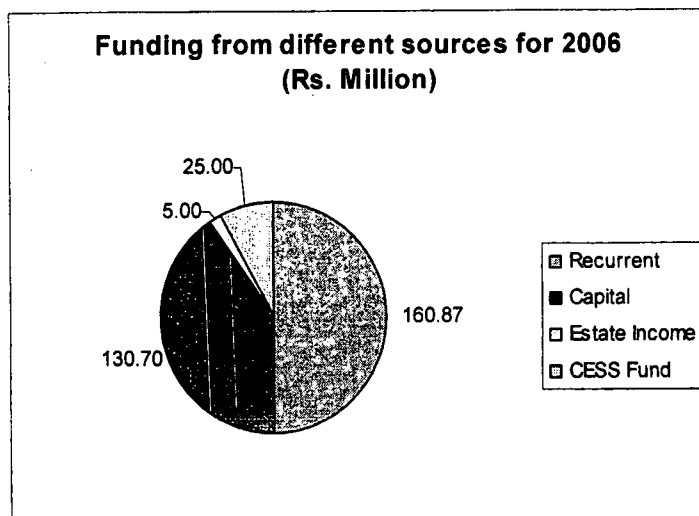
The performance of scientists, extension staff as well as staff of the services divisions maintained at a higher level with team spirit to achieve the set targets of the Institute. Analysis of the Diagnostic survey carried out in the coconut triangle revealed very valuable information for the re-orientation of R & D activities as well as technology transfer programmes as well as the extension services of the Coconut Cultivation Board to address the issues of the stakeholders.

Findings of the diagnostic survey conducted by the Institute presented to the Coconut Research Board as well as the Coconut Development Ministry to take necessary policy directives to develop the industry. Multidisciplinary research approach introduced several years ago maintained with an appreciable progress and significant research output. New findings will be translated into simple technology packages to reap the benefit to the growers and the industry in the future. It was noteworthy that some research achievements are well recognized by the international community and brought pride to the Institute.

Allocation of Funds

Coconut Research Institute receives funding from three main sources namely (i) Consolidated Fund (ii) Coconut Cess Fund, and (iii) Donor Assisted Funds.

The total allocation from the treasury for the year 2006 as Capital and Recurrent Fund was Rs. 25.00 million and Rs. 130.70 million respectively. This was 13 percent increase of the capital funds and 10 percent increase of the recurrent fund compared to the previous year. With the increase of the Cess allocation due to new introduction of vegetable oil import, allocation from the coconut Cess for the development projects proposed by the CRI amounted to Rs. 160.87 million and it was nearly 16 percent increase compared to the previous year. However, total receivables from the Cess fund for special development projects were Rs. 46.761 million. Unexpected delays in awarding of contracts for construction work until fourth quarter and delays in disbursement of Cess funds were the main reasons to this situation.



Funding from various donor-assisted projects amounted to Rs. 3.772 million for 2006. Direct Fund for International Development (DFID), Common Fund for Commodities (CFC) jointly with Asia Pacific Coconut Community (APCC), and Council for Agriculture Research Policy (CARP) continued to fund for two research projects on coconut mite. ADB funded Second perennial crop development project also continued to fund for farmer participatory coconut based intercropping demonstrations up to September, until closure of the project activities. IPBGRI through COGENT also continued to fund the poverty alleviation project site at Dodanduwa and helped tsunami affected families to develop new income generating activities. This project will continue up to 2008. CARP funded project towards the end of the year.

From the Coconut Cess Fund allocation of Rs. 160 million, Rs. 52 million and Rs. 3.6 million respectively allocated for the construction of long awaiting Soils & Plant Nutrition laboratory complex and a plant house for Genetics & Plant Breeding Division.

ACHIEVEMENTS AND HIGHLIGHTS:

1. Research

Major research achievements and highlights are presented in the summary form under five main thrust areas namely crop improvement, crop production, crop protection, processing and value addition, and technology transfer as given below:

1.1 Crop Improvement

During the year enrichment of coconut germplasm with exotic varieties was continued. Eighty coconut plans comprising 12 Gezelle Peninsula tall, 6 PNG brown dwarf, 3 Malayan Red dwarf, 11 Malayan Yellow dwarf, 14 Tenga Tall, 17 Tagnan Tall, 8 West African Tall, 6 Vanatu Tall and 3 Catigan Green Dwarf, raised from embryos brought from Papua New Guinea (PNG) and Ivory Coast were field planted at Bandirippuwa Estate. Twenty two plants obtained from PNG and Ivory Coast material are ready for field planting whereas 27 more plants are at different stages of acclimatization. Only a limited number of plants could be raised from the varieties brought from Ivory Coast due to very poor germination of embryos and 159 of them are still growing in culture media. The Institute took another new step by initiating a crossing programme using imported pollen of three exotic varieties namely Renel Island Tall (RIT), Tegnán Tall (TAGT), and Malayan Red Dwarf (MRD) obtained from Ivory Coast with selected Sri Lanka tall palms at Margaret estate and selected dwarf palms at Isolated Seed Garden, Ambakelle.

Screening of coconut varieties for *Aceria* coconut mite tolerance was continued at Bandirippuwa and extended to Thammanna Estate where experimental site heavily infested with coconut mite. Among five coconut cultivars; tall x tall (TT), dwarf green x tall (DGT), dwarf yellow x tall (DYT), Moorock tall (MT) and plus palm tall (PPT) evaluated at Thammanna Estate, DYT showed satisfactory level of tolerance to coconut mite, though the level of tolerance vary from palm to palm within the cultivar. Among the indigenous cultivars evaluated, Gon Thembili, proved to be a prospective cultivar for mite tolerance. As a result, a crossing programme between GT and SLDY, another mite tolerant indigenous variety identified last year. Along with this crossing combination, another four crosses involving Brazilian Green Dwarf (BGD) in combinations of SLT x BDG, SR x BDG, GT x BDG and BDG x GT were also initiated with the dual objective of development of new coconut cultivars for high yield and mite tolerance.

Three adaptive trials in farmers' fields with Tall x Dwarf Brown in Anuradhapura, Kuliypitiya and Matara were established this year. Total of farmer fields comprising 22 Tall x San Ramon (CRISL 98) and 12 Dwarf Green x San Ramon (Kapruwana) sites were also established during the year in 31 farmers' fields covering 11 districts including Badulla and Moneragala districts.

The molecular tools were employed to identify the casual agents of the leaf disease of coconut and continuation of the coconut genome-mapping project. DNA

extracted from leaf samples of leaf disease affected palms gave positive PCR products with phytoplasma specific primers. Sequencing of the PCR product for the confirmation of the results is to be carried out in 2007. All the seedlings of the mapping population were subjected to DNA fingerprinting based legitimacy test for the specific cross between Dwarf Red and Sri Lanka Tall and 300 seedlings were finally selected for the study. A site at Walpita Estate was identified and land preparation was commenced for the field establishment of the progeny in 2007.

When the embryo cultured plants were exposed to elevated CO₂ during the acclimatization period girth at collar region, shoot, root ratio and root weight of plants increased compared to that of ambient CO₂ showing a positive response on early vegetative growth. A total of 140 in vitro-raised Dikiri plants were transferred to soil for acclimatization. Forty embryo-cultured Dikiri palms were field planted at Middeniya Research Station as a first step in establishing demonstration plot of Dikiri palms in the mini-coconut triangle. Forty embryo-cultured Dikiri plants were distributed among growers.

Investigations on multiplication of immature embryo-derived callus was continued and it was possible to multiply callus by 4-fold. Application of glutamine (2.7 mg/l) for plant regeneration media gave encouraging results. With this treatment, the maximum number of shoots obtained from callus of a single embryo was 22.

The Ovary culture protocol was further improved and a significant increase in shoot regeneration frequency was achieved by incorporating Zip, BAP, and GA₃ growth hormones into the germination medium. The results obtained from the anther culture experiments were quite promising. The ploidy level of the embryos and plantlets derived from anthers was tested using flow cytometry. The results revealed that some of the plantlets were haploid. This is the first time that haploid plantlets were produced from coconut anthers and it has not been reported in any where in the world.

The project on cryopreservation of coconut plumules and mature zygotic embryos conducted in collaboration with IRD, France was completed successfully. Cryopreservation of plumules obtained from five different coconut varieties (Sri Lanka Tall, Dwarf Red, D x T hybrid, Bodiri and Gon Thambili) was attempted. The highest rate of survival and recovery of frozen plumules were obtained in D x T hybrid. The recovery rates of Bodiri and Gon Thambili were very low and in the case of Dwarf Red, none of the frozen plumules could be recovered.

1.2 Crop Production

Rainfall distribution studies carried out by the Institute revealed that rainfall distribution in the second quarter (April-June) of the year was even, compared to 2004, but overall distribution up to September was favourable for coconut production in 2006 and it is expected at least 10% increase in the yield compared to 2005.

A study conducted to determine yield variation pattern at district level, revealed that Puttalam District having highest per palm yield, whereas Kurunegala District gave the lowest per palm yield.

Research in the area of plant nutrition focused towards improving nutrient management in coconut lands particularly with inorganic fertilizer and locally available organic sources. An experiment conducted to formulate site-specific recommendation of fertilizers revealed that application of high doses of N P K, and Mg fertilizers than recommended levels of fertilizer at Mangala Eliya (Borupana series/Dry Zone), Sirigampola (Madampe series/Wet Zone) and Kobeigane (Wariyapola series/Intermediate Zone) always gave 70 to 85 percent increase in yield compared to recommended dosage of fertilizer and the control. These results prove the depletion of nutrients in soils and need for application of more fertilizers.

Comparison of the efficiency of organic and green manure against inorganic fertilizer (APM – W) showed 52% increase in the nut yield of palms receiving poultry manure compared to the control (no fertilizer). The percentage nut yield increase inorganic sources such as cattle manure, goat manure and green manure (gliricidia was 43%, 33% and 22%) over the control respectively.

Nutrient removal studies conducted recently have also shown that nutrient removal from bearing coconut palms is higher than amount supplied as fertilizer. The experiments conducted for determining soil fertility decline in the Dry Zone coconut soils compared with adjacent virgin soils revealed that N, P, K and Mg were less by 15%, 149%, 100% and 140% respectively in coconut grown soils. Same study conducted at Ratmalagara Estate showed major nutrients such as N, P, K and Mg were less by 67%, 42%, 100% and 190% respectively compared with adjacent virgin soils. Thus eroded or leached soils need application of more nutrients to increase production of palms. Application of organic manure like cattle, poultry and goat manures, as well as green manure improved soil fertility as well as soil physical properties giving more benefits to the grower. The soil microbiological properties of these soils also have decreased at a significant level. Therefore, application of more organic matter is very important to improve quality of these soils. Experiments conducted with different P sources have proven that application of Eppawala Rock Phosphate is sufficient to supplement phosphate requirement in the Wet and Intermediate Zone coconut soils.

Drip irrigation at a rate of 40 l palm⁻¹ day⁻¹ and six-day intervals with 12 split application of fertilizer gave 49% increase in yield in Andigama series soil. In that same study, it was shown that irrigation changes the microclimate within the canopy by reducing canopy temperature as well as temperature in the manure circle during the dry period. Cooling effect in the canopy may reduce immature nut fall in the dry period.

A field experiment established at Middeniya Research Station with four improved cultivars namely, TT, DT, TSR, DG x SR (Kapruwana) with the local tall accession "Rumassala" with the objective of developing a package of soil moisture management in the mini coconut triangle to overcome the effect of drought and to evaluate the

performance of four improved cultivars for their potential growth and yield in S1 soil under non water limiting conditions.

Root development and nutrient uptake studies conducted for coconut seedlings grown in different land suitability classes showed that diameter, fresh weight, dry weight, volume and density of large roots higher in S2 and S3 soils compared to that of S4. Higher density of roots observed in S2 soils compared to S4 soils.

Application of glyphosate at the rate of 4.0 l ha⁻¹ and Diuron 3.2 kg ai/ha found to be very effective for coconut nurseries. Where as application of glyphosate 4.0 l ha⁻¹ and subsequent establishment of cover crops such as Pueraria is an economically viable weed control method in mature coconut lands compared to slashing, cattle grazing, and gliricidia planting between coconut rows.

CRI has given special emphasis on promotion of organic coconut farming as it will help to increase farm income. About 25 model farms were established in Kurunegala and Puttalam Districts and activities of those farms were regularly monitored with necessary guidance and inputs such as livestock and other planting material when and where necessary. Farmer awareness workshop on organic coconut farming and certification was conducted in collaboration with the EU Sri Lanka Organic Agricultural Project of the EDB. Experiments conducted with the objective of improving fertility in coconut lands through vermiculture showed the potential of adapting this technology to recycle farmland waste biomass in coconut converted to vermi compost within 4 – 5 weeks, mediation of this process by earth worms. Five vermi compost production units were established in research substations to popularize this technology among growers.

With a view to promote animal husbandry in coconut plantations, a sheep farming project established at Bandirippuwa Estate. A gliricidia leaf meal block that can be stored up to two months was prepared. This block can be fed to the animal mixing with rice bran and coconut poonac up to 50%. There was an increase in the body weight of the animal fed with this block. Therefore, it can be effectively fed during the dry season especially when the availability of quality feed is scarce.

1.3 Crop Protection

The scientists in Crop Protection Division focused their studies on coconut mite on several directions viz. Biology and ecology of the pest, its natural enemies, identifying tolerant coconut cultivars and developing management strategies using biological and chemical methods. In contrast to the rapid increase in the coconut mite population in 2005, a sharp decline was recorded in 2006, reaching approximately 700 mites per nut. High rainfall prevailed during the year and increase of predatory mite population may have reduced the mite population.

New technologies were developed for fast breeding of *Neoserubus bakari*. Field releases of *N bakari* continued at the rates of 2500, 5000 and 10,000 mites per palm, but it did not show an impact on reducing pest density, but the proportion of healthy nuts was

higher in the plots 5000 mites/palm was released. A survey conducted to determine the distribution of *N. bakari* and *N. paspalivorus* in infested areas of different agro-ecological regions confirmed that *N. bakari* was mainly confined to dry areas while both species were found in Intermediate and Wet areas.

The collaborative projects with CABI Bioscience, UK funded by Department of International Development, UK for develop a management method for coconut mite using the entomopathogenic fungus *Hirsutella thompsonii* was completed. Among the fungal isolates identified isolate IMI 391722 indicated that percentage of damaged, normal sized nuts and damaged smaller sized nuts harvest were less in the plots treated at 2 and 3 monthly intervals compared to the untreated plot. A collaborative project with ITI commenced to develop commercial myco-acricide formulation.

Application of 20% palm oil + 0.5% wettable sulphur reduced the population of mite by over 95% up to 03 months. The mixture has no harmful effects on predatory mites and did not cause nut fall.

Under the CFC/DFID/FAO/APCC project on integrated management of black beetle four treatments viz. *Oryctes* Pheromone, Green Muscardine Fungus (GMF), *Oryctes* virus (ORV) OrV+ GMF were evaluated. Black Beetle population decreased over the time with pheromone traps. Technologies for on farm production of GMF using maize grains and Black Beetle larvae were developed and these technologies were transferred to growers through Farmer Field School Program.

Multidisciplinary study group working on Coconut Palm Decline disorders continued to determine the possible causes and remedial measures for Leaf Scorch Decline (LSD), Tapering "Disease" (TD), and Coconut Rapid Decline (CRD). Transmission Electron Microscopy (TEM) image analysis on cellular abnormalities and presence of sub-cellular pathogens did not reveal any phytoplasma or viroid-like bodies in affected palms. Further studies are continuing to determine whether any involvement of fungal toxins, nematodes as well as soil micro-nutrients for this condition.

1.4 Coconut Processing

The Scientists in Coconut Processing Research Division concentrated more on characterization of properties of virgin coconut oil with other oils and to develop various products out of defatted, protein and fibre rich coconut residue. These studies revealed that Virgin Coconut Oil (VCO), King Coconut Oil (KCO), Normal Coconut Oil (CNO) and significantly higher lauric acid (C12:0) content compared to Coconut Paring Oil (CPO) and Palm Kernel Oil (PKO). Among these oils KCO had the highest Linoleic acid (C18:2) content. During deep frying Free Fatty Acid (FFA) content, Peroxide Value (PV), Total Polar Compounds (TPC) and Anisidine value (ANV) of all three oils increased with deep frying but VCO had the lowest rejections points.

The residue obtained after extraction of VCO has high nutritive value having high percentage of fibre and hemicellulose. This defatted coconut flour in varying proportions

used to prepare fibre-enriched bakery products such as cookies. By substitution of defatted coconut flour up to 40% quality of cookies could be maintained while increasing dietary fibre content by about 10 times.

The research team was able to introduce several new food products made out of coconut using dikir coconuts as well as haustorium (Palapi) of the germinating nuts.

Coconut Processing Research Division involved in a study to identify microbes that enhance retting process of coconut husks and isolated twelve different micro-organisms that contribute to fibre retting. Laboratory studies are continuing to isolate most efficient microbes and conditions required to enhance the retting process.

With the emphasis of producing good quality charcoal and dried grated kernel using the waster heat during the process of charcoal combustion a coconut shell combustor which give combustible producer gas and heat recovery unit designed and developed in collaboration with the private sector. Fabrication process of this unit is progressing satisfactorily.

1.5 Socio-Economic Studies

New Agriculture Economics and Agribusiness Management Division established this year and it was housed in a new building constructed.

At the request of Coconut Cultivation Board a survey was conducted to determine the success of Samurdhi coconut development program which conducted jointly by Coconut Cultivation Board and the Samurdhi Authority. The survey revealed that the success rate of the program in terms of the existence of seedlings is greater than 75%.

The new Division has taken up several studies to determine potential fro home gardening in semi-urban areas. Findings of the Agriculture Economists show that there is a huge knowledge gap on proper coconut cultivation technology and accessibility of planting material of improved coconut varieties. By filing this gap yield from home gardens could be increased.

They have undertaken few more studies to determine actual cost of production of coconut products, to measure effect of trade distortion on coconut oil industry.

2. TECHNOLOGY TRANSFER ACTIVITIES

Technology Transfer Division implemented several program to disseminate technology, information and educate extension personnel, coconut growers and other stake holders.

2.1 Research Extension Dialogues

Three research extension dialogues were conducted covering entire regions of the Coconut Cultivation Board. The objectives of these dialogues were to introduce new technologies, identify are specific technology needs and to find solutions for current field problems faced by coconut growers in different coconut areas.

2.2 Educational Programs for Target Groups

A teacher educational program was conducted for Agriculture and Science Teachers in several educational zones in different parts of the island to disseminate new technologies on coconut cultivation and processing. Considering the high potential for expanding and rehabilitating coconut cultivation in the Southern Province several educational programs were conducting for village level officers attached to AGA Division in the Hambantota District.

In order to promote new coconut based products introduced by the Institute, several group demonstrations were conducted in different parts of the island in collaboration with "VIDATHA" centers.

2.3 Crop Clinics

Three cop clinics were conducted at Pallma, Rathmalagara and Maduru Oya Research Substations for the benefit of coconut growers in the surrounding areas. Over 300 participants attended each crop clinic.

2.4 Farmer Field School Program

Farmer Field School Program is a new approach in educating and motivating rural coconut growers to adapt to new technologies. During the year the Technology Transfer Division conducted several adult self educational programs in Galle, Dambadeniya, Anuradhapura, Alawwa, Chilaw, Nikaweratiya and Middeniya.

2.5 Mass Media Programs

"Kapurka Pamula" weekly radio program conducted in collaboration with Coconut Cultivation Board with effective participation of coconut growers and processors. "Kapurka Pamula" weekly newspaper supplement also published in Dinamina Paper (Thursday) to disseminate technology among growers and school children.

Two interactive CD's were produced with the financial assistance of Council for Agricultural Research Policy to disseminate technology among growers.

3. PERFORMANCE OF THE GENETIC RESOURCE CENTERS AND RESEARCH CENTERS

3.1 General Performance

All the Genetic Resource Centers and Research Substations operated as self financed units by the Estates Management Division. Part of the profits (Rs. 5 million) generated by the Division contributed to the Institute.

During the year a total of 5,700,241 nuts were produced from the total palm population comprising 75,417 fully bearing palms and 3,400 partially bearing palms. The yield included 1,289,912 seed nuts from Genetic Resources Centers. This was an increase of 39.5% of seed nut supply compared to the corresponding period in the previous year. The income from the sale of nuts and sundries was Rs. 52.9 million and Rs. 8.61 million respectively. This is an increase of 27.7% and 8% than the previous year. The increase of yield was attributed to evenly distributed rainfall with increased number of wet days during the year 2005 and adoption of appropriate cultural practices. The overall Cost of Production (COP) for all estates averaged as Rs. 7.89 with a net sales average of Rs. 9.28. The gross profit was 12.11 million giving a net profit of Rs. 8.86 million.

3.2 Development Activities Undertaken

Establishment of Middeniya Research Station was continued with noteworthy progress during the year. Uprooting of 920 mango trees was completed and 1040 coconut seedlings were planted under three experiments. A deep well was excavated and the pump house was constructed. A nursery was started by laying 15,500 seed nuts for demonstration purposes. Land vehicles including one four wheel tractor, one trailer, one two-wheel tractor and one bowser purchased. Livestock activities were commenced with a herd of 14 cattle.

Makandura Genetic Resource Center was redeveloped with the assistance of Cess funds. Weak palms were selected and uprooted while inter crops were established in vacant areas of the estate. Priority was given for application of organic manure.

A drip irrigation system was established at the Genetic Resource Center – Ambakelle, in an extent of 75 acres with the assistance of Cess funds to increase the production of CRIC 65. A new field was divested for hybrid production by planting 350 dwarf seedlings in alternate rows of tall palms.

4. MAINTENANCE OF INSTITUTE PROPERTIES AND NEW CONSTRUCTIONS

Engineering Unit attended to all building, vehicle, road, water and electrical maintenance activities.

4.1 New Constructions

- Construction work of the two- storey laboratory building for insect rearing was completed.
- Construction of the circuit bungalow and OIC quarters at Middeniya are near in completion
- Construction of the Sales outlet at Bandirippuwa Research Centre was completed.
- Contact for the construction of two storied laboratory complex for the Soils & Plant Nutrition Division was awarded to Finite Lanka Private Limited.

4.2 Renovations

- Renovation of the existing Club House building is in progress.
- Renovation of CPRD Office completed.
- Renovation of BE/GRIII/34 Bandirippuwa Research Centre was completed.
- Renovation of BE/GRIII/23 at Bandirippuwa Research Centre was completed.
- Renovation of BE/GRI/16 at Bandirippuwa Research Centre was completed.
- Renovation of BE/GRI/22 at Bandirippuwa Research Centre was completed.

5. NEW INITIATIVES

5.1 Seeds and Seedling Production and Certification Unit

Activities of the Seeds and Seedling Production and Certification Unit commenced with the certification of seedlings in the CCB nurseries. Seedling certification was commenced initially to certify only polybaged seedlings of cultivars CRIC 60 and CRIC 65 only. During the year, eleven estates were selected as plus palm estate for the supply of seed nuts for the National Replanting Program. Registration was provided to five private coconut nurseries.

REPORT OF THE AGRONOMY DIVISION
Acting Head - S.H.S.Senarathne M.Sc

1. GENERAL

The research program of the Agronomy Division was primarily aimed at i) increasing coconut yield, and ii) increasing land productivity through development of innovative agronomic practices. During the year, 18 field experiments were conducted under 8 major research projects. The total allocation of consolidated funds in terms of capital and recurrent budget for these studies was Rs. 4.435million. In addition, two projects were conducted with the objectives of improvement of soil fertility in coconut plantations through vermiculture and development and popularization of organic products and processing of coconut. The total budget allocation of CESS funds in terms of capital and recurrent budget for these two studies was Rs. 2.685million. Two out side funded projects, namely the Livelihoods and Natural Resources Restoration for Tsunami Victims in Dodanduwa project (IPGRI, Rs. 0.53 million) and Enhancing Food Security, Nutrition and Micro Credit Systems in Coconut Growing Communities in Sri Lanka project (IPGRI, Rs. 0.4million) were also in operation during the year.

Various field experiments were continued with a common goal of rehabilitating low yielding coconut plantations via improved cultivation practices. Under this category, planting of T x T coconut seedlings in 1.3 m x 1.3 m pits in Andigama shallow soils showed significantly higher leaf production over the year, showing the advantages of large size planting holes.

Planting of gliricidia to optimize the production of fuel wood and foliage biomass in coconut plantations showed that, the highest wood biomass was recorded in plots with three rows of gliricidia while the lowest was in plots with single gliricidia rows.

Intercropping cashew with coconut did not adversely affect coconut yield as observed in previous year indicating cashew as a potential intercrop under coconut.

In weed management experiment, application of Glyphosate at the rate of 4liters/hectare twice a year effectively suppressed the weed growth in coconut lands. Cover cropping treatment with Pueraria phasiolodues was equally effective in suppressing monocotyledonous and dicotyledonous weeds. Both treatments also showed significantly higher nut yields over the control treatments.

Sheep farming is a very effective method to control problematic weeds and improve soil fertility level in coconut lands. Thus to develop and popularize sheep farming in coconut plantations, one field demonstration was initiated in Bandirippuwa estate.

The CESS funded project on "Improvement of Soil Fertility in Coconut Lands through Vermiculture" showed that the promising potential of adapting this technology to recycle farm land waste biomass in coconut plantations. The waste biomass (weed and plantation residues and animal wastes) can be very easily converted to compost fertilizer 4 to 5 weeks within the mediation of worms. Five vermicompost production units have been established in CRI research substations to popularize this technology among coconut growers and to reduce the cost of production in coconut plantations. Five filed experiments were

established to evaluate the effect of vermin compost on coconut seedling growth and nut yield.

Twenty model farms were established in the coconut triangle under the "Popularization of Organic Coconut Production and Processing Project" funded by CESS and these are supervised and monitored with necessary guidance and inputs such as livestock and other planting material when and where necessary. Farmer awareness workshop on "Organic Coconut Farming and Certification" was conducted in collaboration with the EU-Sri Lanka Organic Agriculture Project of the EDB.

2. RESEARCH PROJECTS

PROJECT 1: REHABILITATION OF LOW YIELDING PLANTATIONS

Experiment 1.3: Effect of root pruning and fertilizer application on yield of coconut palms with heavy root mat formation on Coastal Regosols (DL4/S5), Palavi - 1996

The experimental design was a Randomised Complete Block Design (RCBD) with three replicates containing nine effective palms per plot. The soil was sandy Regosols characterized by a high water table that varies from 60 cm to 150 cm from the surface between the wet and dry seasons. In year 2006, root pruning by disk harrowing (15 cm depth) and application of 3.0 kg of APM + 1.0 kg of dolomite/palm were continued according to treatments given in Table 1.

Table 1: *Effect of three different treatments on the yield of coconut at Palavi*

Treatments	Nuts/palm/year			
	2003	2004	2005	2006
T2-Harrowing + Fertilizer	56	58	48	53
T3-Harrowing only	40	49	29	36
T4-Fertilizer only	49	58	44	60
Significance	n.s.	n.s.	n.s.	*
LSD (P=0.05)				

The analysis of data in year 2006 showed that T3 is significantly different from T2 and T4 but there was no significant difference between T2 and T4 (Table 1). This indicates that there are no any significant effects from harrowing in the coconut square. However, Research Committee of the CRI suggested harrowing to be done in the manure circle itself. Further, there was an increase in nut yield in all treatments compared to year 2005 (T1 was removed due to unavoidable circumstances).

The experiment is in progress.

*H A J Gunathilake, K V N N Jayalath,
S D J N Subasinghe and E M G Banda*

Experiment 1.4.2: Effect of size of planting hole on the growth of T x T seedlings on the Andigama Soil Series (shallow phase): Rathmalagara Estate (IL1/S5) Madampe - 1997

The objective of this experiment was to determine whether the growth performance of T x T coconut seedlings could be improved by increasing the size of the planting hole and by changing physical and biological properties of soil with loamy soils. Treatments given in Table 2 have been arranged in a Randomized Complete Block Design (RCBD) with three replicates. There were nine effective palms per plot.

Unlike in year 2004, significant differences were observed in total number of fronds among treatments. Seedlings planted in standard size pits had the lowest number of leaves compared to other treatments. The highest number of fronds was recorded in seedlings planted in 1.3 x 1.3 x 1.3 m pits. The results suggest that planting of coconut seedlings in large pits would be more beneficial to overcome the problems in shallow Andigama soils.

Table 2 shows the extent of reproductive attainment as a percentage of palms flowered in year 2006. However, the results appeared as same as in year 2005.

Table 2: The effect of size of planting holes on early growth of seedlings

Treatments	Total Number of fronds/palm	Number of leaves produced	Flowering %
T1 1 x 1 x 1 m pit (standard planting hole)	10	6	5
T2 1.3 x 1.3 x 1.3 m pit (filled with husk/same soil)	14	8	17
T3 1.3 x 1.3 x 1.3 m pit (filled with husk/soils brought from out side)	13	8	33
T4 1.3 m wide x 1.3 m deep trench (filled with husk/same soil)	11	7	41
T5 T4 + 20% increased standard density of palms (156/ha)	12	8	58
Significance	*	*	
LSD (P=0.05)	3.8	0.8	

Eight years after planting in large pits and filling with good soil increased the flowering up to 33%. However, trench planting showed higher flowering percentage suggesting that there are other factors involved.

The experiment is in progress.

*H A J Gunathilake, K V N N Jayalath, H A Abeysona,
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Experiment 1.4.5: Rehabilitation of degraded coconut soils through short-term forestry in Andigama Soil Series (shallow phase) at Ratmalagara Estate (IL1/S5), Madampe - 1999

This experiment was initiated in October 1999 to investigate the possibility of improving soil quality of degraded coconut lands through short/medium term forestry for economical coconut production. The forest tree species used in this experiment have been planted in a Randomized Complete Block Design (RCBD) with three replicates (Table 3).

In year 2006, the three *Acacia* species followed by *Macaranga paltata* (Kenda) showed higher growth rates as measured by stem girth at 30 cm and 130 cm above ground (Table 3). The growth rate of *Calophyllum elatum* (Domba) remained significantly low as in the previous years. Growth of *Gliricidia sepium* and *Grewia tilifolia* was also low.

Table 3: Growth of selected forest tree species

Treatments	Stem girth (cm) (at 30 cm above ground)		Stem girth (cm) (at 130 cm above ground)	
	2005	2006	2005	2006
T1 <i>A. auriculiformis</i>	55	82	48	66
T2 <i>A. mangium</i> -1	60	66	51	62
T3 <i>A. mangium</i> -2	60	62	51	58
T4 <i>Calophyllum elatum</i>	20	22	16	18
T5 <i>Grewia tilifolia</i>	33	35	21	24
T6 <i>Macaranga paltata</i>	53	58	47	51
T7 <i>Gliricidia sepium</i>	27	35	24	37
T8 <i>Tectonia grandis</i>	42	54	36	44
T9 <i>Swietenia acrophylla</i>	34	36	27	29
T10 <i>Bridella mooni</i>	46	49	37	41
Significance		n.s.		n.s.
LSD (P=0.05)	***		***	
CV%	13		14	

The experiment is in progress.

*H A J Gunathilake, N A K de Silva, K V N N Jayalath,
H A Abeysona and I M Thilakerathne*

Experiment 1.5: Use of different plant species to rehabilitate coconut soils

Experiment 1.5.1: Rathmalagara Estate (IL1/S4) - 2005
Experiment 1.5.2: Ridigama Oya Estate (IL1/S4) - 2006

The objective of the experiments were to develop a suitable method to rehabilitate coconut soils, because prolong cultivation of coconut leads to degradation of lands in many areas of the country. The soil organic matter levels decrease gradually in these lands due to high temperature and some other factors inherent to tropical climates. The organic matter content in coconut soil lies in the range of 0.05% - 2%, which is very low. To maintain high

soil fertility in coconut lands, the organic matter content and other properties have to be improved. This can be done by incorporation of different plant materials into the soil.

Therefore, two experiments were established at Rathmalagara Estate and Ridigama Oya Estate using following treatments on a Randomized Complete Block Design with three replicates. There were 8 effective palms per plot.

Treatments: T1- Planting *Gliricidia sepium*
T2- Planting *Gliricidia sepium* + *Thitonia diversifolia*
T3- Planting *Panicum maximum*
T4- Planting *Thitonia diversifolia*
T5- Control (no plant species)

The experiments are being continued.

*S H S Senarathne, K C P Perera,
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Experiment 1.6: Performance of different planting materials on Andigama Series Lateritic Soils and the effect of irrigation on the growth of deep planting coconut seedlings.

Experiment 1.6.1: Bandirippuwa Estate (IL1/S5) - 2005

The objective of the experiment was to determine the effect of irrigation and different planting materials on seedling establishment and subsequent growth of deep planted coconut seedlings in Andigama Series Lateritic (deep gravel) soils. Experiment was established at Bandirippuwa estate using following treatments on a Two Factor Factorial Randomized Complete Block Design with three replicates. There were 8 effective coconut seedlings per plot. Seedling holes (4ft x 4ft x 4ft) were excavated by using a backhoe machine. Irrigation was done during the drought periods. Seedling growth was measured and expressed as seedling girth and height.

Treatments: T1 - With Irrigation + Tall x Tall seedlings
T2 - With Irrigation + Plus palms seedlings
T3 - Without Irrigation + Tall x Tall seedlings
T4 - Without Irrigation + Plus palms seedlings

Table 4: *Effect of different treatments on the growth of coconut seedlings expressed as the seedling girth and height (cm) in 2006.*

Treatments	Seedling girth (cm)			Seedling height (cm)		
	April	Aug	Dec	April	Aug	Dec
T1 - With Irrigation + Tall x Tall seedlings	30	41	57	246	296	341
T2 - With Irrigation + Plus palms seedlings	32	39	50	254	306	356
T3 - Without Irrigation + Tall x Tall seedlings	28	36	49	239	271	310
T4- Without Irrigation + Plus palms seedlings	29	36	52	248	273	310
Significance	ns	ns	ns	ns	ns	ns
LSD (P=0.05)						

Growth of coconut seedlings as expressed by the seedling height (cm) and seedling girth (cm) was measured (Table, 4). Both growth parameters were not significantly different at the end of year 2006.

The experiment is being continued.

S H S Serarathne, K C P Perera, R Sawarnathilake, and B. Perera

PROJECT 2: SOIL MOISTURE CONSERVATION

Experiment 2.1: Effect of husk burial, irrigation and fertilizer application on coconut yield, Rathmalagara Estate, Madampe, 2006

The study was aimed at evaluating the effect of husk burial, irrigation and fertilizer application on coconut yield. The treatments are shown in Table 5. Coconut yield data were collected during the year 2005 to capture the pre-treatment variation. There were no significant differences between treatments during the year 2006. However, the effect of pre-experiment coconut yield was significant.

Table 5: *Effect of husk burial, irrigation and fertilizer application on coconut yield*

Treatments	Nuts/palm/year
	2006
T1- Fertilizer only	76
T2- Irrigation only	83
T3 - Husk pits only	94
T4 - Irrigation + husk pits + fertilizer	90
T4-Fertilizer + Irrigation into husk pits	86
Significance	n.s.
LSD (P=0.05)	-

*H A J Gunathilake, K V N N Jayalath,
H A Abeysoma and E M G Banda*

PROJECT 3: IMPROVEMENT OF PRODUCTIVITY OF COCONUT SOILS THROUGH VERMICULTURE TECHNOLOGY

Experiment 3.1: Effect of vermin-compost on the growth of coconut seedlings under field conditions

Experiment 3.1.1: Mendis Estate, Badalgama (IL1/S4) - 2006

Experiment 3.1.2: Seram Estate, Yakwila (WL3/S4) - 2006

The objective of this experiment was to evaluate the effect of vermin-compost on the growth of coconut seedlings. Therefore, two experiments were established at Badalgama (Mendis Estate) and Yakwila (Seram Estate), using following treatments with Randomized Complete Block Design with three replicates. Seedling growth was measured and expressed by the seedling girth, height and leaf number.

Treatments: T1 - Vermi-compost only (100%)
T2 - Inorganic fertilizer (YPM 100%)
T3 - Vermi-compost (50%) + Inorganic fertilizer (YPM 50%)

The experiments are being continued.

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Experiment 3.2: Production of vermin-compost by using different weed species, at Bandirippuwa Estate - 2006

The objective of this experiment was to produce vermicompost by using plant residues from different weed species which grow in coconut plantations. The experiment was established at Bandirippuwa estate with following treatments on a Complete Randomized Design with four replicates. Worm multiplication percentages, nutrient content of vermin-compost and allilopathic effect of vermicompost on the growth of different vegetables are evaluated.

Treatments:

T1 - Cow dung 1/3 (v/v) + Grass residues 2/3 (v/v)
T2 - Cow dung 1/3 (v/v) + Grass residues 1/3 (v/v) + Chromoleana odorata residues 1/3 (v/v)
T3 - Cow dung 1/3 (v/v) + Grass residues 1/3 (v/v) + Lantana camara residues 1/3 (v/v)
T4 - Cow dung 1/3 (v/v) + Grass residues 1/3 (v/v) + Hyptis suaveolens residues 1/3 (v/v)
T5 - Cow dung 1/3 (v/v) + Grass residues 1/3 (v/v) + NFT,s residues 1/3 (v/v)

The experiment is being continued.

S H S Senarathne, K C P Perera, R Sawarnathilake, and B. Perera

PROJECT 4: DEVELOPMENT OF BIOMASS ENERGY PRODUCTION SYSTEMS UNDER COCONUT

Experiment 4.1: Planting of Gliricidia to optimise the production of fuel wood and foliage biomass under coconut at Ratmalagara Estate (IL1/S5), Madampe - 2003

The experimental design was a Randomised Complete Block Design with four replicates. The following treatments were imposed with the objective of studying the effect of plant density on fuel wood and foliage biomass of Gliricidia.

- T1- Planting one row of Gliricidia at 1 m spacing (1275 trees per ha)
- T2- Planting two rows of Gliricidia at 2 x 1 m spacing (2550 trees per ha)
- T3- Planting two rows of Gliricidia at 1 x 1 m spacing (2550 trees per ha)
- T4- Planting three rows of Gliricidia at 1 x 1 x 1 m spacing (3825 trees per ha)

Treatments had significant effects on the wood biomass but not the foliage biomass yield of Gliricidia after three years of planting (Table 6). The annual average wood biomass production has increased from 2004 to 2006 and it is significantly different between years. The highest wood biomass was recorded in plots with three rows of gliricidia while the lowest was in plots with a single gliricidia row. However, plots with higher plant densities had a low wood and foliage biomass yield per tree (data not shown). Although treatments 2 and 3 had equal plant densities, the wider spacing gave higher wood and foliage biomass yields.

The experiment is in progress.

Table 6: Wood and foliage biomass yield of gliricidia as affected by different planting densities

Treatment	Wood yield(kg/ha)			Foliage biomass (kg/ha)		
	2004	2005	2006	2004	2005	2006
T1- One row (1275 trees/ha)	1 495	3 341	3 012	539	1 335	2 080
T2- Two rows (2550 trees/ha)	2 525	5 432	5 656	873	1 511	2 307
T3- Two rows (2550 trees/ha)	1 887	4 399	4 646	574	1 020	1 383
T4-Three rows (3825 trees/ha)	2 917	7 698	5 902	746	1 559	1 778
Significance	n.s.	*	*	*	*	n.s.
LSD (P=0.05)		1 923	2 139	301	281	
CV%		23		27	12	

H A J Gunathilake, K V N N Jayalath, H A Abeysona and E M G Banda

PROJECT 5: ORGANIC COCONUT FARMING

Experiment 5.1: Effect of different organic manure applications on the performance of mature coconut palms at Ratmalagara Estate (IL1/S5), Madampe - 2003

An experiment was started in year 2003 with the objective of assessing the effect of organic fertilizer application on soil fertility and coconut yield. Following treatments were imposed on a non replicated single plot experiment and each plot had 24 effective palms. The age of the palms was 55 years and they have been planted at a spacing of 8.5 m X 8.5 m.

T1 - Application of 3 kg of APM +1 kg of Dolomite

T2 - Application of 50 kg of Gliricidia +230 coconut husks +600 g of ERP +1 kg of Dolomite

T3 - Application of 25 kg of goat manure + 130 coconut husks +600 g of ERP + 1 kg of Dolomite

T4 - Application of 30 kg of Gliricidia + 230 coconut husks + 600 g of ERP + 1 kg of Dolomite + Puraria cover crop

Table 7: *Effect of different organic manure applications on coconut yield*

Treatments	Coconut Yield (nuts per palm)		
	2004	2005	2006
T1	63	74	86
T2	79	55	85
T3	51	75	104
T4	62	60	79

There was no difference in nut yield among the treatments T1, T2 and T4. This shows that Gliricidia and cover crops are possible substitutes for chemical N of Urea. However, palms treated with goat manure supplemented with other organic and natural mineral sources (T3) showed 30 % nut yield improvement. This indicates that as a source of biological N, goat manure is more beneficial than Gliricidia. However, Gliricidia is cheaply available as an in-situ N source in coconut lands.

The experiment is in progress.

*H A J Gunathilake, B A S Manjula,
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Experiment 5.2: Effect of organic manure application on the performance of T x T coconut seedlings at PSG (IL1/S4)-2006

The experiment was designed to evaluate the prospects and constraints of raising coconut seedlings using 100% organic inputs. Treatments shown in Table (8) were laid on Randomize Complete Block Design (RCBD) with three replicates and six effective palms per plot. During the year, experimental plots were treated according to the treatment plan indicated in table (7)

- Treatments:** T1-control (YPM + 1000 g of Dolomite)
 T2-Vermicompost (5 kg + 200 g of ERP + 250 g of Dolomite)
 T3-Gliricidia (5 kg + 275 g of ERP + 250 g of Dolomite)
 T4-Cattle or Goat manure (5 kg + 200 g of ERP + 250 g of Dolomite)

Table 8: *Treatment plan of the experiment at Pallama Seed Garden*

Treatment	Ingredients	Basa l	0.5 year	1 year	1.5 year	2 yea r	2.5 yea r	3 yea r	3.5 yea r	4 yea r
T 1	Urea (g)	250	150	180	180	240	240	300	300	360
	ERP (g)	750	340	405	405	540	540	675	675	810
	MOP (g)	250	150	180	180	240	240	300	300	360
	Dolomite (g)	1000	500	500	500	500	500	500	500	500
T 2	Vermicompost (kg)	10	5	6	6	8	8	10	10	12
	ERP (g)	390	200	240	240	320	320	400	400	480
	Dolomite (g)	500	250	250	250	250	250	250	250	250
T 3	Gliricidia (kg)	10	5	6	6	8	8	10	10	12
	ERP (g)	540	275	330	330	440	440	550	550	660
	Dolomite (g)	500	250	250	250	250	250	250	250	250
T 4	Goat dung (kg)	10	5	6	6	8	8	10	10	12
	ERP (g)	390	200	240	240	320	320	400	400	480
	Dolomite (g)	500	250	250	250	250	250	250	250	250

Table 9: *Effect of different treatments on growth performance of T x T coconut seedlings at Pallama Seed Garden*

Treatments	Average No of leaves June 06	Average No of leaves Dec 06	Average girth (cm) June 06	Average girth (cm) Dec 06	Average height (cm) June 06	Average height (cm) Dec 06
T1control	5	7	13.5	27.3	125.3	179.9
T2Vermicompost	4	6	13.6	28.5	124.6	189.6
T3Gliricidia	4	7	12.4	26.0	118.2	181.6
T4 Goat manure	4	7	13.1	25.9	124.6	181.1
Significance	ns	ns	ns	ns	ns	ns

During the year, number of leaves per palm, basal girth and height of the palm have not shown any significant difference among treatments. This is probably due to over-shading of external supply of nutrients by accumulated nutrients available in the coconut seedlings during initial period.

B A S Manjula, R Marasinghe, W R O Fernando

PROJECT 6: DEVELOPMENT OF LOW COST WEED MANAGEMENT SYSTEMS FOR COCONUT LANDS AND COCONUT NURSERIES

Experiment 6.1: Comparison of several recommended cultural practices for weed management in coconut lands

Experiment 6.1.1 Pallama Seed Garden (IL1/S4) - 2000

Treatments shown in Table 5 were laid on RCBD with three replicates and there were nine effective palms per plot. Different weed management treatments were applied according to the schedule. During the year, more frequent sampling was practiced to understand the dynamics of weed growth in response to different cultural practices of weed management. Soil samples were taken to measure soil moisture content at two depths (0.5ft and 1.0ft). The major weed species present in these sites were Illuk (*Imperata cylindrica*), Mana (*Panicum repens*), Getakola (*Hedyotis auricularia*), Podisinghomaran (*Chromolaena odorata*), Gadapana (*Lantana camara*) and Nidikumba (*Mimosa pudica*).

- T1 - Control treatment (in which only the perennial shrubs were managed)
- T2 - Cover cropping with Pueraria
- T3 - Planting Gliricidia (in double rows in an avenue at 1m x 2m spacing)
- T4 - Slashing (two times per year)
- T5 - Application of Glyphosate (4 lit/ha, two applications per year)
- T6 - Grazing with cattle (6 rotations per year)

There were significant differences in weed biomass among treatments. The lowest weed biomass was recorded in Glyphosate applied and Pueraria cover plots. Pueraria cover was also equally effective to suppress weeds as in Glyphosate applied plots (Table 10). Nut yield of coconut as affected by the application of different cultural practices showed significant differences during the year (Table 11). The highest nut yield was recorded in chemical weeding and cover crop planted plots. Soil moisture content was significantly higher in Glyphosate applied plots at 1.0 feet depth (Table 12).

Table 10: Weed biomass (g/m²) at different sampling times as affected by the application of different weed control practices at Pallama Seed Garden, Pallama

Treatments	Ave 01	Ave 02	Ave 03	Ave 04	Ave 05	Jan 06	Mar 06	May 06	July 06	Sept 06	Nov 06
T1- Unweeded	238	168	179	133	212	174	143	202	154	138	199
T2- Cover crop	193	135	16	0	0	0	0	0	0	0	0
T3- Gliricidia	216	129	150	88	143	112	88	35	116	102	98
T4- Slashing and mulching	168	126	146	106	154	68	143	189	37	128	137
T5- Chemical weeding	150	39	28	46	50	0	20	34	18	69	85
T6- Cattle grazing	227	147	189	135	167	162	137	86	180	135	142
Significance						**	**	**	**	**	**

LSD (P=0.05)						42	60	28	65	56	67
CV%											

All the treatments were applied in June 2006 and December 2006.

Table 11: *Nut yield of coconut as affected by different cultural practices in controlling weeds at Pallama Seed Garden, Pallama*

Treatments	2001	2002	2003	2004	2005	2006
T1- Unweeded	72	26	68	82	62	70
T2-Covercrop (Pueraria)	88	38	87	101	94	91
T3- Gliricidia	77	38	74	84	59	79
T4-Slashing and mulching	78	27	81	87	75	76
T5-Chemical weeding	81	44	97	102	99	93
T6- Cattle grazing	83	36	75	81	66	75
Significance	n.s.	n.s.	*	*	*	*
LSD (P=0.05)			15	13	17	14
CV%						

Table 12: *Soil moisture content (%) as affected by different cultural practices in controlling weeds at Pallama Seed Garden Pallama*

Treatment	Soil Moisture Content (%)			
	2005		2006	
	0.5 ft (depth)	1.0 ft (depth)	0.5 ft (depth)	1.0 ft (depth)
T1 - Unweeded	2.73	4.25	2.42	3.34
T2 - Cover crop (Pueraria)	4.72	4.31	3.66	5.62
T3 - Gliricidia	3.48	4.81	2.92	4.65
T4 - Slashing and mulching	3.25	4.37	2.61	4.27
T5 - Chemical weeding	2.37	8.20	2.38	6.32
T6 - Cattle grazing	4.68	4.50	3.62	4.05
Significance	n.s.	*	n.s.	*
LSD (P=0.05)	-	3.88	-	1.7

Conclusion:

Application of glyphosate at 1.44 kg ai/ha and cover cropping with Pueraria were the most effective treatments for the control of weeds in mature coconut plantations. However, management of the cover crop is essential to avoid possible competition between coconut palms and the cover crop.

The experiment was terminated

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PROJECT 7: SMALLHOLDER COCONUT FARMING SYSTEMS WITH ANNUAL/PERENNIAL CROPS IN THE INTERMEDIATE AND THE DRY ZONE

Experiment 7.1: Evaluation of the performance of grafted cashew under coconut Rthmalagara Estate, Madampe (IL1/S4) - 1995

Treatments given in Table 13 were tested on a RCBD with three replicates. Each plot consisted of nine effective coconut palms.

Planting of cashew in coconut avenues did not affect coconut yield as in previous years suggesting cashew as a potential intercrop in coconut plantations (Table 13). Grafted cashew reached early flowering and yielded within two years of planting followed by air-layered cashew plants. After 7 years of plantation, both types of vegetatively propagated cashew produced a yield of over 5.0 kg/tree/year. Cashew propagated by seeds took more than five years to flower, but from the 7th year onwards, produced the highest yield among other types. However the difference is not significant. Bud-grafted cashew produced the highest yield per unit basis. It was noted that unpredicted rains during the flowering period resulted in low cashew yields in year 2006.

Table 13: *The effect of the type of cashew on coconut yield*

Treatments	Coconut yield (nuts/palm/year)		
	2004	2005	2006
Coconut monoculture	79	50	80
Bud grafted cashew	75	51	70
Air-layered cashew	70	40	78
Seedling cashew	67	51	74
Significance (P=0.05)	n.s.	n.s.	n.s.

The experiment is in progress.

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b. Pallama Seed Garden (IL1/S4) - 2000

Intercropping with cashew did not show any significant effect on coconut yield as observed in the previous year (Table 14). At Pallama site, cashew yields were not taken because of severe pest damage.

Table 14: *Coconut yield as affected by intercropping with three different types of planting materials of Cashew*

Treatments	Coconut yield (nuts/palm/year)		
	2003	2005	2006
Coconut monoculture	66	51	79
Bud grafted cashew	72	64	93
Air-layered cashew	68	61	92
Seedling cashew	69	58	90
Significance (P=0.05)	n.s.	n.s.	n.s.

The experiments are in progress.

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PROJECT 8: VELOPMENT OF SMALLHOLDER COCONUT FARMING SYSTEMS WITH LIVESTOCK (SMALL RUMINNENTS) INTERGRATION IN THE INTERMEDIAT AND DRY ZONE.

**Demonstration 8.1: Development of smallholder sheep farming system to increase the productivity of Coconut lands.
Bandirippuwa Estate. (IL1/ S4) - November 2006.**

The objectives of this demonstration are to assess the profitability of sheep farming under coconut and effectiveness of sheep in control of weeds. Twelve red madras and bickernery cross bred sheep were introduced to 0.75 acre of paddock in November 2006. Male to female ratio was 1:10. Adaptation period was 4 months.

The initial dry matter percentage was 31%. *Brachieria brizantha*, *Brachiaria miliformis*, *Pueraria phaseoloides* and weeds were the main feeds available in the paddock. Average body weight of a female sheep at the beginning of the experiment was 21 kg.

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Experiment 8.1: Cultivation of Coimbatour 3 (CO-3) fodder under coconut to improve the productivity of coconut lands.

Bandirippuwa Estate. (IL1/ S4) - November 2006.

This experiment was planned to study the effect of CO-3 on nut yield and to determine the optimum level of nitrogen fertilizer for CO-3 under coconut. Experiment design was Randomized Complete Block Design (with 3 replicates) with 6 Effective palms per plot.

Treatments: Nitrogen Fertilizer level
 T1- Control (0kg of Urea/ha)
 T2- 30 kg of Urea/ha/year
 T3- 45 kg of Urea/ha/year
 T4- 60 kg of Urea/ha/year
 5- 75 kg of Urea/ha/year

Spacing of CO-3 plants – 2m x 1m

Approximately 3 acre land was ploughed and levelled. CO-3 seedlings were planted in one feet deep holes and 1 kg of goat and sheep manure was applied after planting.

Fertilizer treatments will be applied in Yala and Maha seasons. CO-3 will be close cut at 2 month intervals during the year. The soil type of the experimental site was Boralu series (S4). Soil nutrient status was measured before the experiment (Table, 15). Nut yield records were also maintained.

Table 15: *An average nutrient content of the CO3 experimental site (mg/kg)*

N	P	K	Ca	Mg
630.5	9.37	0.29	0.28	0.33

Forage dry matter yield will be recorded at the time of close cutting.

The experiment is in progress

S.C.Somasiri, H.A.J.Gunathilake, M.D.V.Saparamadu

Experiment 8.2: Preservation of low cost feed to overcome the scarcity of feeds during dry season. Ratmalagara Estate. 2006

The objective of the experiment is to introduce Gliricidia Leaf Meal Block (GLMB) and/or complete feed block as a source of protein to ruminants. Leaves of Gliricidia stem lopping were collected and dried up to 20% moisture. It was ground to small pieces and pressed into blocks of 4 x 4 inches using a briquette machine.

Two pre test feeding trials were conducted to test the palatability and effect of the block on animals. First trial was conducted using two milking Zebu cows and feeding them with the GLMBs showed an increasing trend in the production of milk. The second trial was conducted using one year old female calves. Feeding GLMBs did not affect the body weight gain of calves indicating that this can be effectively used to feed ruminants when the basal feed is limited.

This experiment is in progress to find out different ways to improve the quality of the block.

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3. RESEARCH PROJECTS FUNDED BY OUTSIDE AGENCIES

3.1: Development of sustainable coconut-based income generating technologies in poor rural communities - (IPGR) Project

The project on "Livelihood and natural resources restoration for tsunami victims in Dodanduwa, Sri Lanka" was implemented at Dodanduwa, Sri Lanka with the objective of restoring income generating activities of Community Base Organization (CBO) members in Dodanduwa and nearby communities to establish CBO managed community activities that would foster enhanced food security and nutrients; and to restore natural resources which includes crops, animals, soil and water; and mangroves.

Under this project, ten training activities on home garden farming systems (vegetable nursery beds, compost production and vegetable cultivation) were completed. Sixty rope making machines, 20 doormat making equipments with toolkits and coconut fibre were distributed among CBO members to produce coconut fibre ropes and doormats. They are now earning about US \$ 2-3 per day. A new geo-textile producing centre has been established in Dodanduwa by CBO members and 50% of the ropes made are used to produce geo textiles and the rest is used to produce doormats.

Two hundred home gardens have been established. Five banana suckers, 10 cassava sticks, 5 types of vegetables and 2 fruit plants have been planted in every home garden two to three Dwarf x Tall coconut seedlings (depending on the size of the land) and one Tall x Tall coconut seedling per home garden were distributed in September 2006. Most tsunami affected CBO members can produce their own vegetables from the home gardens.

In addition, the introduction of coconut based livestock systems (poultry and cattle) and home garden based intercropping systems have generated a good income for these rural communities. Poultry and cattle farming have been identified as the most effective livestock intervention activity to generate income among tsunami affected people. Two incubators have been installed in two communities to loan out chicks among farmers.

S H S Senarathne, M J I Costa and W R O Fernando

4. SELF-FINANCED PROJECTS

4.1: Fuel wood plantation project - Pallama Seed Garden, 1998 (IL1/S5)

A fuel wood plantation with Gliricidia and Acacia has been established to study the potential of dendro-thermal power generation in coconut lands. Coconut lands categorized as S4 and S5 are the most suitable for planting Nitrogen Fixing Trees (NFT's) and this will generate an additional income to the grower.

At present, the fuel wood plantation covers 18 hectares with 30,000 and 5,000 Gliricidia and Acacia trees respectively. The production details are given in Table 16.

The total marketable wood yield has increased by only about 1% compared to the previous year. However, the increase in net profit is about 44% compared to the previous year mainly due to the reduction in total expenditure related to maintenance and operation of the plantation.

Table 16: Production details of the fuel wood plantation, Pallama Seed Garden

Description	Data
Number of harvests during the year	2
Wood yield per tree/year	14.2 kg
Total wood yield	69519.0 kg + 76000 sticks
Total income	Rs. 254820.05
Total expenditure	Rs. 204310.25
Net profit	Rs. 50509.80

The project is in progress.

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5. MISCELLANEOUS STUDIES

5.1: Demonstration farm, Thabbowa, Nattandiya

The farm, which consists of 2.5 ha is being managed on a self-financing basis to demonstrate improved cultural practices in coconut lands and to increase productivity of lands by intercropping with selected crops such as cinnamon and pepper.

The farm had a net profit of Rs. 159 832.18 in year 2006 (Table 17).

Table 17: Annual income and expenditure of demonstration farm, Thabbowa

Income			Expenditure	
Item	Quantity Nuts/Seedlings	Value Rs.	Item	Value Rs.
Sale of coconut	32 898	356 949.00	Labour	448 882.07
Sale of coconut seedlings			Others	94,659.00
Poly bagged T x T			Electricity	277 370.00
D x T	2 417	145 020.00	Seed nuts	277 370.00
R.D	1761	105 660.00		
K.C	85	5 100.00		
Bare rooted T x T	-	-		
D x T				
Other	10 452	313 560.00		
	730	21 900.00		
C. Sale of other crops	3 238	10 441.25		
		39 048.00		
Total Income		997 678.25		837 846.07
Profit:		159 832.18		

H A J Gunathilake and P Fernando

5.2: Animal breeding program

The animal-breeding programme at Maduruoya and Pothukulama are being continued to provide improved breeds of buffalo and goats to coconut growers. The number of male and female heads remained at each site at the end of the year are given below (Table 18).

Table 18: *Animal breeding program*

Place	Breed	Adults		Calves		Total	
		F	M	F	M	F	M
Maduruoya	Moora	26	12	03	05	29	17
PRS	Sri Lankan Boer	61	07	20	26	81	33

H A J Gunathilake and S H S Senarathne

6. FIELD DEMONSTRATIONS

6.1: Demonstration of effect of different cultural practices on yield of coconut grown in S1 lands (S1/IL1) Bandirippuwa Estate

Different cultural practices were imposed on coconut (Dwarf x Tall) grown in S1 lands to demonstrate importance of them for high production of nut yield. The soil was deep sandy loam and physical limitations for nut production were minimal.

Nut yield among different treatments varied highly. Coconut palms even without any maintenance practices including fertilizer application yielded 120 nuts/palm/year mainly due to high suitability of soil (Table, 19). Coconut palms responded well to fertilizer plus green manure application which yielded 184 nuts/palm/year. The difference between fertilizer application vs no fertilizer was 44 nuts/palm/year (Table, 19). A response for soil moisture conservation practices was not seen due to performance in S1 lands.

Table 19: *Nut yield as affected by different management systems in coconut plantations*

Treatments	Mean yield (2001 - 2005)	Nut yield 2006
T1 - No management	110	120
T2 - Weed control only	104	125
T3 - weed control + moisture conservation only	94	119
T4 - Weed control + fertilizer application	116	164
T5 - Weed control + fertilizer application + moisture conservation	95	137
T5 - Weed control + fertilizer application + moisture conservation + cover crop	111	151
T6 - Weed control + moisture conservation + green manure (<i>Gliricidia</i>) + Supplementary inorganic fertilizer	119	184
T7 - Weed control + fertilizer application + moisture conservation + supplementary organic fertilizer	101	143

6.2: Development and popularization of organic coconut production and processing in Sri Lanka

The project was implemented in the coconut triangle with the objective of development and realization of farm models, which promote organic agriculture with a prospect to offer a better income to the producers and to develop an alternative strategy over chemical coconut farming relying on biological processes in natural eco-systems and establish self-sufficient and sustainable coconut production systems/models with internationally accredited organic certificates.

This project is implemented in two phases as indicated below.

Phase I: Establishment of organic coconut farming models in main coconut growing areas of Sri Lanka

Phase II: Popularization of organic coconut farming among coconut small holders in the country

Under the project, twenty one conventional coconut lands were identified (Table 20) as potential model farms. These are being converted to organic model farms with comprehensive conversion plans for each farm. One milking cow was provided to the Mawathagama site to improve the organic manure production system of the site. Other model farms were introduced with inter-cultivation of Gliricidia and improved pasture.

Table 20: Details of organic farming demonstration sites

District: Kurunegala				
Name of the owner	Location	Land extent (acre)	Number of bearing palms	Present status of Livestock and intercrops
1. Mr. M S Tennakoon	Madawa, Pilassa	9.5	450	Cattles - 04 Pepper - 02 acres
2. Mr. A R S Anwer	Mallawapitiya, Kurunegala	9	325	Pepper - 460 bushes
3. Dr. K W Ranasinghe	Kumbalnga, Ibbagamuwa	25	1600	Cattles - 10
4. Mr I U Waragoda	Walamitiyawa Narammala	20	1100	Banana - 01 acres Foliage - 05 acres Kiriala Cattles - 01
5. Mr J A D K Jayasinghe	Bandawa, Polgahawela	10	500	Banana - 02 acres Vanilla - 200 vines
6. Mr H B Dissanayake	Thalawa, Moragollagama	7	390 young palms	Banana - 750 plants CO3 - 01 acres Mango - 40 plants
7. Mr N Wijeratne	Ridigama	156	5400	Buffalo - 24 Neat cattle - 63
8. Mr K H S Kumarasinghe	Wathuwatta Dummalasuriya	5	300	CO3 - 0.5 acres Banana - 0.5 acres Kiriala - 0.25 acres Buffalo - 30 Neat cattle - 17 Goat - 10
9. Mr A Subasinghe	Morakele Estate, Sandalankawa	24	650	Banana - 2.5 acres
10. Mr S Kaluarachchi	Boyawalana Keppitiwalana	25	2000	Pepper Cattle - 04
11. Mr Wikrama Rodrigoo	Velipenna	25	960	Pepper - 02 acres Lime - 03 acres Banana - 03 acres CO3 - 06 acres
12. Mr Susantha Hapuarachchi	Velipenna	20	960	-

District: Gampaha				
Name of the owner	Location	Land extent (acre)	Number of bearing palms	Present status of Livestock and intercrops
1. Mr S Karunaratne	Kannimahara Estate, Waturugama	10	400	-
2. Mr W S D Ariyawansa	Walpita	7	430	Bettle - 01 acres Buffalo - 08 Neat cattle - 10
3. Mr K J Kuruppu	Marapola, Weyangoda	10	740	Pepper - 02 acres Banana - 02 acres Cattle - 05
4. Mrs M S M de Silva	Hapitigama Kal Eliya	40	1600	Rambutan - 70 plants Cattle - 10
5. Mr R S U Ranaweera	Dharmarama Mawatha Gampaha	30	1500	Banana - 01 acres Kiriala - 0.5 acres Neat cattle - 10
6. Mr R S Athulathmudali	Uggalboda Gampaha	16	900	Banana - 01 acres Durian - 07 plants Buffalo - 01 Neat cattle - 04
District: Puttalam				
Name of the owner	Location	Land extent (acre)	Number of bearing palms	Present status of Livestock and intercrops
1. Mr U Karunaratne	Peace Haven Estate Puliyanakara	50	2400	Bettle - 0.5 acres Mango - 0.5 acres
2. Mr C P de Silva Jayaratne	Madampe Estate Madampe	50	1400	CO3 - 04 acres Neat cattles 25
3. Mr Ervan Perera	Kandawatta Mugunuwatuwana	13.5	1600	Cashew - 75 plants

Nut production records, input and output relations, cost of production and net sales average of coconut are being collected.

The project is being continued.

*B A S Manjula, R Marasighe, W R O Fernando, M D Saparamadu,
K D D Appuhamy, S Warnakula, E M G Banda*

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REPORT OF THE GENETICS AND PLANT BREEDING DIVISION

Head- Lalith Perera PhD, UK

1. GENERAL

Commencement of a crossing programme involving exotic coconut varieties, initiation of a crossing programme for development of coconut hybrids for anticipated *Aceria* mite tolerance, initiation of a crossing programme for development of a mapping population segregating for mite tolerance, establishment of two coconut gene banks at Middeniya Research Station and at Margaret Estate, Pallama and carrying out molecular diagnostics for identification of causal agent for the coconut leaf rot disease in the Southern Province were the new research programmes commenced during the year 2006 at the Genetics and Plant Breeding Division. The ongoing experiments; Evaluation of existing cultivars, Evaluation of progenies, Evaluation of new coconut cultivars in farmers' fields, Evaluation of dwarf brown crosses in multi-locations, Maintenance of existing gene banks, Field establishment of exotic germplasm, Genotyping and evaluation of mapping population, Screening of coconut varieties for *Aceria* mite tolerance were continued successfully during the year. Commencement of certification of coconut seedling, selection of new plus palm estates, initiation of selfing programme for San Ramon (SR) at Andigama Farm, Giriulla and initiation of a crossing programme among selected Sri Lanka Talls (SLT) at Pallama Seed Garden (PSG) for production of planting materials for further expansion of PSG, field establishment of 243 seedlings belonging to 18 half-sib families at Maduru-Oya Seed Garden (MOSG), initiation of a work programme for establishment of a new seed garden for mass production of coconut cultivar; Kapruwana (GD x SR) and establishment of a research linkage between Genotyping Support Service of the Generation Challenge Programme (GCP) of the IPGRI towards identification of marker-trait association through linkage and association mapping in coconut were other noteworthy achievements during the year.

The main event of note of the year was the initiation of a crossing programme involving three exotic coconut varieties; Rennel Island Tall (RIT), Tagnanan Tall (TAGT) and Malayan Red Dwarf (MRD) which were of Southeast Asian and the Pacific origin for development of new coconut cultivars for high yield. The pollen were imported from Ivory Coast and fifteen palms each of selected SLT palms at Margaret Estate were crossed with RIT, TAGT and MRD while twenty each Sri Lankan Green Dwarfs (SLGD) were crossed with RIT and TAGT at the Isolated Seed Garden (ISG). This experiment was started as a result of the recent findings through molecular studies that coconut in Sri Lanka has a narrow genetic base and mixing of exotic genetic materials specially materials from Southeast Asia and the Pacific are necessary for further exploitation of hybrid vigour.

Screening of coconut varieties for *Aceria* mite tolerance was continued at Bandirippwa Estate (BE) and extended to evaluate existing coconut cultivars for the same trait at Thammanna Estate (TE), Puttalam where the experimental site was heavily infested with *Aceria* mite. Among five coconut cultivars; Tall x Tall (TT), Green Dwarf x Tall (GDT), Yellow Dwarf x Tall (YDT), Moorock Tall (MT) and Plus Palm Tall (PPT) evaluated at TE, DYT showed a satisfactory level of tolerance to *Aceria* mite, though the level of tolerance vary from palm to palm within the cultivar. Among the indigenous cultivars evaluated, Gon Thembili (GT) proved to be a prospective variety for mite tolerance. As a result, a crossing programme between GT and Sri Lanka Yellow Dwarf (SLYD), another mite tolerant indigenous coconut variety identified last

year, was initiated. Along with this crossing combination, another four crosses involving Brazilian Green Dwarf (BGD) in combinations of SLT x BGD, SR x BGD, GT x BGD, BGD x GT were also initiated with the dual objectives of development of new coconut cultivars for high yield and mite tolerance. This pollination programme was continued at BE, Margaret Estate and at the ISG. Furthermore, another pollination programme was commenced at ISG to develop a mapping population segregating for the *Aceria* mite tolerance character involving twenty one (21) highly tolerant SLYD palms and a single SLT palm which is highly susceptible to *Aceria* mite. The objective of this programme is the identification of genes/QTLs responsible for the mite tolerant character. Variety and cultivar evaluation for response to mite attack was done in collaboration with the staff of the Crop Protection Division.

Two new gene banks, one at Middeniya and the other at Margaret Estate were established during the year. Total of 304 seedlings comprising three new accessions; Rumassala, Kurunagala and Deegawapi were field planted at Middeniya while 95 Ran Thembili, 29 Gon thembili, 68 Bodiri, 5 Kamandala, 8 Porapol, 41 Sri Lanka Red dwarf (SLRD), 30 Cameroon Red Dwarf (CRD), 27 Murusi, a new coconut phenotype identified in Unawatuna area last year, 80 coconut seedlings raised from seed nuts collected at Muthiyangana were also field planted at the new gene bank at Margaret Estate. Morphological characterization of stem, inflorescence, fruit and leaves were continued during this year also for 28 palms from 4 different new phenotypes identified and collected from Unawatuna area. During the year, enrichment of coconut germplasm with exotic varieties was continued and 80 coconut seedlings comprising 12 Gezelle Peninsula tall, 6 PNG Brown Dwarf, 3 Malayan Red Dwarf, 11 Malayan Yellow Dwarf, 14 Tenga Tall, 17 Tagnanan Tall, 8 West African Tall, 6 Vanuatu Tall, 3 Catigan Green Dwarf, brought as embryos from Papua New Guinea and Ivory Coast and *in-vitro* raised at the Tissue Culture Division were field planted at BE. Attempts made to import Hainan Tall, which is a cold tolerant coconut variety in China failed this year.

Three adaptive trials in farmers' fields with tall x dwarf brown in Anuradhapura, Kuliyaipitiya and Hakmana were established during the year. Total of 34 farmer fields comprising 22 Tall x San Ramon (TSR or CRISL98) and 12 Sri Lanka Green Dwarf x San Ramon (GDSR or Kapruwana) sites were also established during the year in 31 farmers' fields covering 11 districts. For the first time adaptive trials were established in Badulla and Monaragala districts.

Analysis of yield data confirmed the superiority of dwarf x tall hybrids over the tall cultivars in the evaluation of cultivars trials both at BE and Suriyapura Estate (SE) this year too. No significant differences were observed among three tall cultivars TT, MT and PPT in both sites. Respective yields (nuts/ha) of GDT, YDT, TT, MT and PPT at BE were 20200, 18200, 14600, 13000 and 14200. The yield was not statistically significant between GDT and YDT at BE during the year when GDT reported the highest yield among all cultivars at SE (19,000 nuts/ha) and it was significantly different to the yield of YDT (16,200 nuts/ha). The respective yields (nuts/ha) of TT, MT and PPT at SE were 11600, 12400 and 11400.

During the year yield and fruit component data were recorded from three previously abandoned sites of progeny trial; Mudalihamy at Andigama Farm in Giriulla and Sirikandura Estate in Rathgama where T x SR was replicated along with other three sites at BE, Daisy Valley

Estate (DV) and Rathmalagara Estate (RE) and Puras block at Andigama Farm in Giriulla where GDSR was replicated along with the site at DV and two observational blocks at RE and BE, in order to study the cultivar x environment interaction for formulation of more precise site specific recommendation for coconut cultivars. The cross GD x SR continues to be the best copra producer per unit area at DV under favorable soil conditions. However the comparative advantage of GDSR in copra production is reduced in marginal soils as revealed by the fruit component analysis at Puras and observational block at BE sites. The cross T x SR remains to be the best per nut copra producer at all sites.

During the year a new site at BE was identified and site preparation was commenced to establish another multi-locational experiment of the brown dwarf crosses. Growth measurements were recorded at Raddegoda Estate, RE and Wanathawilluwa sites at six monthly intervals.

The highlights of the molecular work of the division during the year were the employment of molecular tools to identify the causal agents of the leaf rot disease of coconut and continuation of the coconut genome mapping project. DNA extracted from leaf samples of leaf rot disease affected palms gave positive PCR products with phytoplasma specific primers. Sequencing of the PCR product for the confirmation of the result is to be carried out in 2007. All the seedlings of the mapping population were subjected to DNA fingerprinting based legitimacy test for the specific cross between Sri Lanka Red Dwarf x Sri Lanka Tall and 298 seedlings were finally selected for the study. A site at Walpita Estate was identified and land preparation was commenced for the field establishment of the progeny in 2007.

The key activity under the services and development functions of the division this year was the commencement of coconut seedling certification in the CCB nurseries. Seedling certification was commenced initially to certify only polybagged seedlings of cultivars CRIC60 and CRIC65 only. During the year, eleven estates were selected as Plus Palm estates for the supply of seed nuts for the National Replanting Programme. Registration was provided to five private coconut nurseries. Under the CESS assistance, upgrading of the ISG was continued and 460 green dwarf seedlings were established there by converting a high density tall stand into a dwarf-tall mixed field. A pollination programme involving 50 selected SLT palms in various combinations at PSG and selfing programme of 25 SR palms at Andigama Farm, Giriulla were also commenced this year, in addition to the SR selfing programme continued at Pothhukulama Research Station (PRS) for production of TT and SR planting materials for further expansion of PSG. During the year expression of interest was called from private and government sector organizations to join with CRI to establish a new seed garden for mass production of Kapruwana coconut cultivar and several responses were received. This activity is to be continued next year.

PROJECT: EVALUATION OF EXISTING CULTIVARS (1983/86)

Experiment 12.1.1 Evaluation of five improved cultivars; Green Dwarf x Tall (GDT or CRIC65), Yellow Dwarf x Tall (YDT or CRIC65), Tall x Tall (TT or CRIC60), Moorock Tall (MT) and Plus Palm Tall (PPT)

Design: Randomized block with 4 replicates **Plot size:** 20 palms/plot
Planting distance: 25' x 25' x 25' **Planting density:** 200 palms/ha

Table 1: *Locations and agro-climatic conditions*

Exp. Number	Location	Year established	Soil type	Agro-ecological zone
12.1.1	Bandirippuwa (BE)	1983	Loamy surface horizon with gravelly hard iron-stones (S4)	Wet intermediate
12.1.2	Thammenna (TE)	1983	Latasol	Dry
12.1.3	Palugaswewa (PE)	1985	Sandy clay loam	Dry intermediate
12.1.4	Suriyapura (SE)	1986	Lateritic-gravel	Wet

Yield recording (nuts/palm/pick) continued in sites at BE and SE during the year. Although long term yield data gathered over a period of last 12 years at BE and 9 years at SE were available in hard copies, digitalizing of data for statistical analysis could not be completed this year due to shortage of staff. Therefore only the data pertaining to year 2006 was statistically analyzed while general trends of the performance of cultivar were assessed through yearly total yields.

Trial at BE completed 23 years in this year. The two hybrids, GDT and YDT continued to outperform other tall cultivars (TT, PPT and MT) under average management conditions with total annual yield of 20,200 nuts/ha and 18,200 nuts/ha respectively this year. The difference between two hybrids was not statistically significant at BE but the difference between hybrids and other three tall cultivars were statistically highly significant. The averages yields of TT, MT and PPT were 14,600 nuts/ha, 13,000 nuts/ha and 14,200 nuts/ha respectively and there was no significant difference among these three cultivars.

The mean yield of the same experiment established 3 years after the establishment of BE site, at SE representing the majority lateritic gravel soil in Gampaha district and the wet zone generally showed the same yield trend with respect to yield of hybrids and tall cultivars though the yield difference between GDT and YDT were significantly different and were 19,000 nuts/ha and 16,200 nuts/ha respectively. The mean yield of other three cultivars were (TT, MT and PPT) were 11,600 nuts/ha, 12,400 nuts/ha and 11,200 nuts/ha respectively and there was no significant difference among these three cultivars.

The results confirmed the superiority of two hybrids than the tall cultivars in both sites again this year despite the general belief of farmers that gravely soil in Gampaha district is unfavourable for hybrid coconut cultivation compared to growing tall cultivars. However, the overall yield reduction in all the cultivars at SE compared to BE seemed to attribute to the difference between the environments in the two sites particularly the marginal soil at SE, though the site is benefited from less moisture stress, site SE being situated in wet zone. The palms at site BE on the other hand seemed to take advantage of the loamy surface horizon of the soil for its comparatively better performance despite the site being situated in the wet intermediate zone. This clearly indicates the importance of both soil type and the climatic zone where the coconut is grown in determining the yield potential of coconut cultivars.

The long term yield data at all sites will be analyzed next year in order to reveal any cultivar x site interaction. This would provide adequate information for site specific recommendations for coconut cultivars together with their precisely estimated yield potential at different sites.

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PROJECT: ON-FARM EVALUATION OF NEW CULTIVARS

Experiment 12.1.2 Evaluation of CRISL98 (TSR or Tall x San Ramon) and Kapruwana (GDSR or Green Dwarf x San Ramon) under farmer conditions

Production of CRISL98 was continued by hand pollinating 100 tall palms at ISG with San Ramon pollen from palms at PRS. This programme produced a total of 3437 seed nuts during the year 2006. Fifty more tall palms were selected and pollination programme was initiated at the Field 1 of PSG. Seedling issue for planting was done after inspecting the field and the extent of the sites was restricted to a minimum of one acre and a maximum of two acres. A total of 2439 seedlings were issued to 23 interested growers, 4 in Puttalam district, 6 in Kurunegala district, 3 in Gampaha and 2 each in Kegalle, Anuradhapura, Hambantota and 1 each in Kalutara, Polonnaruwa districts and further for the first time to 2 farmers in Moneragala district. Monitoring of these sites is in progress.

Production of Kapruwana was continued at ISG during the year by hand pollinating 50 dwarf green palms with San Ramon pollen and a total of 2065 seed nuts were produced in 2006. The seeds were raised at ISG and issued to growers on the same conditions set out for issuing CRISL98. During the year, 1196 Kapruwana seedlings were issued to 12 growers; 3 in Kegalle district, 2 each in Gampaha and Puttalam districts and 1 each in Kurunegala, Anuradhapura, Polonnaruwa and Badulla districts.

During the year 102 sites out of 124 sites (119 CRISL98 and 5 Kapruwana) established during the period of 1999-2005 were inspected and 39 well maintained sites were selected for further monitoring.

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PROJECT: IDENTIFICATION OF PARENT PALMS FOR THE USE IN THE BREEDING PROGRAMME. RESPONSE OF GENOTYPES TO YEARLY CHANGES IN WEATHER AT ISG, AMBAKELLE

Experiment 12.2 Programme for the improvement in nut size and nut number in The Isolated Seed Garden (1993) at Ambakelle and Maduru Oya Seed Garden (1995)

The experiments at ISG and MOSG completed 15 and 13 years after planting respectively. These families are still maintained as observational trials until they reach the yield stability to commence yield recording and fruit component analysis and assessment of physiological parameters. It is expected to collect yield data from ISG site from next year onwards.

L Perera and M H L Padmasiri

Experiment 12.7.3 Evaluation of Green Dwarf x Debarayaya Tall (Raddegoda)

This trial was maintained satisfactorily and yield data recording from this trial continued.

C K Bandaranayake, L Perera and G K Ekanayake

Experiment B-8.6 Evaluation of hybrid crosses utilizing local and exotic germplasm to test the potential for sap production and yield (1997)

This trial maintained satisfactorily as an observation trial. Fruit Component analysis will be carried out next year.

S A C N Perera L Perera and H M N B Herath

PROJECT: EVALUATION OF PROGENIES OF SELECTED AMBAKELLE TALL PALMS CROSSED TO SELECTED TALL, GREEN DWARF, YELLOW DWARF AND SAN RAMON IN DIFFERENT COMBINATIONS AND EVALUATION OF THE PROGENY IN MULTILOCATIONAL TRIALS

Design: 3 varieties in 3 sub-plots in a randomized block design with 3 replicates (Blocks).

Plot size: No. of palms/variety/sub-plot: 10 palms

No of palms/variety/Block: 30 palms

Table 2: *Locations and agro-climatic conditions*

Location	Year of establishment	Soil type	Agro ecological zone
Bandirippuwa (BE)	1986	Loamy sand	Wet intermediate zone
Ratmalagara (RE)	1986	Lateritic	Dry intermediate zone
Andigama-Puras	1986	Lateritic	Dry intermediate zone
Andigama-Mudalihamy	1986	Sandy loam	Dry intermediate zone
Mangala Eliya	1987	Loamy sands	Dry zone
Daisy Valley (DV)	1987	Clay loam	Wet intermediate zone
Sirikandura	1989	Lateritic	Wet Zone

Crosses: Tall x Green Dwarf (TGD), Tall x Tall (TT), Tall x San Ramon (TSR), Green Dwarf x Tall (GDT) (only at DV site), Green Dwarf x San Ramon (GDSR) (only at DV site and observation trial at Puras block in Andigama), Open pollinated tall (OP) (only at Mangala Eliya site), Yellow Dwarf x Tall (YDT) (only at Sirikandura)

The recommendation of the two new cultivars CRISL98 (TSR) and Kapruwana (GDSR) was based on the results of this long term research project. However the recommendations were based only on the sites BE and RE for recommending the CRISL98 and only DV for recommending Kapruwana as data recording had been abandoned previously in Andigama-Puras, Andigama-Mudalihamy and Sirikandura sites due to various drawbacks. However, last year it was decided to re-start yield recording in the abandoned three sites in addition to the yield recoding carried out at BE, RE and DV and fruit component analysis at Andigama-Puras and Sirikandura in addition to the site at DV. The purpose of recommencing of data from these sites was to make fine adjustments with respect to the suitability of growing CRICSL98 and Kapruwana under various environmental conditions and to determine the potential yield of these cultivars in each environment. Consequently, only the experimental site at Mangala Eliya remained abandoned during the year 2006. In addition to the above listed multi-locational sites a block comprising of GDSR planted in the year 1968 (38 years old) at Bandirippuwa Estate was discovered. Nuts taken from these palms were subjected to fruit component studies to evaluate the cross GDSR.

Nut yield recording was continued for the eleventh consecutive year in experimental sites at BE and RE sites and for the fifth year at DV site. Counting of nuts of the most mature 6 bunches was carried out throughout the year at 4 monthly intervals at Mudalihamy and Puras blocks at Andigama Estate and at the last quarter at Sirikandura Estate. Nut counting has been identified as a better measurement than the counting of pick yield in order to avoid the underestimation of nut yield due to immature nut fall and theft. Fruit component analysis was also carried out in experimental sites at Puras block, DV and Sirikandura Estates.

Table 3: *Total mean nut yield and standard deviation (in parenthesis) in different crosses in the year 2006 in each site.*

Site	Cross					
	TSR	TGD	TT	GDSR	GDT	TYD
BE	72.6 b (32.3)	100.7 a (46.9)	89.4 a (39.1)	-	-	-
RE	69.6 b (29.9)	108.1 a (43.5)	103.4 a (39.4)	-	-	-
DV	45.7 c (20.6)	66.7 a (23.7)	47.6 c (24.2)	56.4 b (29.8)	62.4 ab (27.4)	-
Puras	53.9 b (25.1)	72.3 a (34.6)	44.7 c (21.9)	67.8 a (32.7)	-	-
Mudalihamy	70.6 a (33.5)	83.7 a (38.9)	76.9 a (33.6)	-	-	-
Sirikandura*	24.9 a (13.5)	21.7 a (10.0)	24.0 a (12.1)	-	-	22.5 a (10.8)

(* Nut yield only for the final quarter of the year 2006)

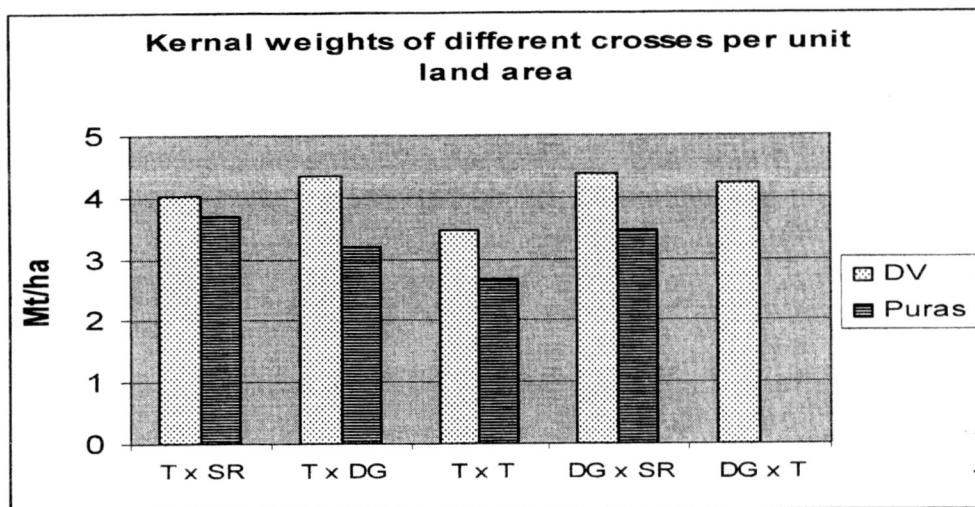
Mean separation has been done among crosses within each site. Means with the same letter are not significantly different at $\alpha = 0.05$

During the year the general nut yielding pattern listing from higher to low is, TGD, GDSR, TT followed by TSR in all sites except at site Puras where the nut yield of TSR exceeded that of TT and the difference is statistically significant. Statistically significant differences in nut yield among crosses were observed only in sites BE, RE, DV and Puras as shown in the table 1, though other two sites maintained a similar order in ranking the cultivars according to yield. The results at all sites indicated the superiority of crosses involving GD in nut production, once again reiterating the superiority of inter varietal hybrids over intra varietal hybrids for nut production at all different environments; only the magnitude of the yield being different between environments.

The fruit component (FC) data given in table 2 confirmed previous information on the superiority of TSR for its fresh nut weight (FNW) and weight of all the other fruit components [husked nut weight (HNW), split nut weight (SNW) and kernel weight (KW)] retaining its status at all sites as the best per nut copra producer in this year too. TSR was followed by TT and GDSR and then by TGD for all fruit components at all sites except for site DV, where GDSR surpassed TT for the weight of HNW, SNW and KW. GDSR continued to be the best copra producer per unit area in DV site (figure 1), as a result the decrease in copra content per nut in

GDSR is more than compensated by the difference in the nut yield. In contrast, TSR retained its superiority in terms of copra content per unit area at the Puras site as a result of substantially low copra content per nut recorded by GDSR in that site. This indicates the reduction in comparative advantage of GDSR in copra production in marginal soils.

Figure 1: Productivity of different crosses per unit land area at DV and Puras sites



Analysis of long term data collected will be undertaken next year for obtaining a clearer view on the long term performance of these cultivars under different agro ecological regions.

*S A C N Perera, L Perera, H M N B Herath,
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Table 2: Means for fruit components of different crosses at different sites

Fruit component - site	Cross					
	T x SR	T x DG	T x T	DG x SR	DG x T	T x DY
FNW – DV	2003.0a	1436.0d	1661.2b	1574.1c	1420.3d	-
Puras	1678.5 a	1067.5 d	1478.6b	1257.0c	-	-
Sirikandura	1794.5a	1321.6b	1697.5a	-	-	1189.6b
BE	-	-	-	1492.4	-	-
HNW- DV	931.7a	660.8e	753.2c	792.6b	684.7d	-
Puras	742.3a	446.3d	652.5b	549.2c	-	-
Sirikandura	805.2a	555.0 b	750.9 a	-	-	573.3b
BE	-	-	-	767.0	-	-
SNW – DV	703.4a	511.6d	590.1b	593.6b	532.4c	-
Puras	561.8a	358.9d	504.2b	414.6c	-	-
Sirikandura	607.6a	441.4b	567.7 a	-	-	451.0 b
BE	-	-	-	562.3	-	-
KW – DV	440.2a	326.9e	362.1c	388.0b	338.9d	-
Puras	342.6a	221.7d	298.9b	254.5c	-	-
Sirikandura	373.2 a	274.6 b	352.02a	-	-	278.7 b
BE	-	-	-	369.8	-	-

Mean separation has been done among crosses within each site. Means with the same letters are not significantly different.

PROJECT: EVALUATION OF THE HYBRID VIGOUR OF BROWN DWARF X TALL, TALL X BROWN DWARF AND BROWN DWARF X SAN RAMON FOR YIELD AND TOLERANCE TO MOISTURE STRESS IN DIFFERENT AGRO-ECOLOGICAL ZONES

Design: Randomized block with 4 replicates **Plot size:** 6-9 palms/plot
Planting distance: 26' x 26' square **Planting density:** 64 palms/ac

Table 5: Locations and agro-climatic conditions

Exp. NO.	Location	Year established	Soil type	Agro-ecological zone
4.1	Raddegoda Estate	2004	Clay Loam	Dry intermediate
4.2	RE	2005	Lateritic gravel	Dry intermediate
4.3	Wanathawilluwa	2005	Latozols	Dry zone
	BE	2007	Sandy loam	Wet intermediate

During the year, growth parameters (girth, height and rate of leaf production) were recorded twice, at the three sites. As some initial variations in height and girth between individual seedlings and among varieties were observed, girth and height measurements taken at 6 months after planting were considered as the covariates when analyzing the data collected from this trial to study the varietal differences in terms of growth rate.

At Raddegoda site only the rate of leaf production showed significant differences among different cultivars after 2 ½ years of planting (Table 3). All Dwarf x Tall hybrids showed a higher rate of leaf production compared to two Tall x Tall hybrids; Tall x San Ramon and Tall x Tall.

Table 6: Rate of leaf production at Raddegoda site

Variety	Mean rate of leaf production
Green Dwarf x San Ramon	4.95a
Green Dwarf x Tall	4.7a
Tall x Brown Dwarf	4.64a
Brown Dwarf x Tall	4.60a
Brown Dwarf x San Ramon	4.54ab
Tall x San Ramon	4.09bc
Tall x Tall	3.54bc

(Means with same letters are not significantly different, $p < 0.05$)

At RE, rate of leaf production and girth measurements showed significant differences among cultivars after 1½ years of planting (Table 4). Green Dwarf x San Ramon (GDSR) showed the highest rate of leaf production and Brown Dwarf x Tall (BDT) and Brown Dwarf x San Ramon (DBSR) performing equally well. Among the cultivars Tall x Brown Dwarf (TBD) showed the lowest and significantly different mean girth.

Table 7: Rate of leaf production and girth measurements at RE site

Variety	Mean rate of leaf production	Mean girth
Green Dwarf x San Ramon	3.41 a	45.00a
Brown Dwarf x San Ramon	3.28 ab	46.07a
Brown Dwarf x Tall	3.05 abc	45.62a
Green Dwarf x Tall	2.92 bc	42.98a
Tall x Brown Dwarf	2.91 bc	38.04b
Tall x San Ramon	2.71bc	42.59a
Tall x Tall	2.66 bc	42.63a

(Means with same letters are not significantly different, $p < 0.05$)

At Wanathawilluwa site only the mean girth and mean height showed significant differences among cultivars 1 year after planting (Table 5)

Table 8: Mean girth and mean height at Wanathawilluwa site

Variety	Mean height	Mean girth
Green Dwarf x San Ramon	244.34a	39.76a
Tall x San Ramon	240.32ab	38.51ab
Green Dwarf x Tall	227.58abc	37.06abc
Tall x Brown Dwarf	235.13ab	36.79abc
Tall x Tall	210.22c	35.94bc
Brown Dwarf x Tall	224.83bc	33.78 bc

(Means with same letters are not significantly different, $p < 0.0001$)

During the year physiological parameters were recorded at Raddegoda site under favorable conditions to compare the variation in physiological traits among crosses. A similar set of data will be collected during a natural drought in order to compare the response of crosses to moisture stress.

The data pertaining to physiological measurement at Raddegoda site was analyzed and it showed that GDSR has a significantly ($P < 0.01$) higher (40%) rate of photosynthesis (A) under favorable weather conditions at Raddegoda (IL3) experimental site. Higher stomatal conductance (g_s) of GDSR indicated that a minimal limitation for gaseous exchange at the stomatal level under favourable conditions compared to the rest of varieites. These higher g_s appeared to have contributed for this higher rate of photosynthesis and obviously the observed higher rate of transpiration (E). Even with higher E , DG x SR managed to maintain comparatively higher instantaneous water use efficiency ($\omega_{inst} = A/E$) along with BDT, TBD, BDSR which showed higher A . Higher photosynthetic rate of GDSR in favorable environmental conditions indicates its potential for higher yields under such favourable conditions. The cultivars TT, TSR and GDT, showed average A and g_s resulting in a comparatively low ω_{inst} under favorable conditions. However, evaluation with long-term data especially under water deficit conditions is essential prior to any conclusions. Data collection is in progress at Raddegoda site.

Physiological data collection will be started at RE (IL1) and Wanathavilluwa (DL3) sites next year.

Land preparation for establishment of a new site of the same experiment was commenced and field is ready for planting during the *yala* season 2007.

Three adaptive trials were established in three farmer fields in three different ecological zones; Anuradhapura (100 seedlings), Kuliypitiya (160 seedlings) and Hakmana (80 seedlings).

*H D M A C Dissanayake, L Perera,
A Fernando and A Nainanayake (PPD)*

PROJECT: CROSSES OF SRI LANKAN TALL AND SRI LANKAN GREEN DWARF WITH EXOTIC POLLEN AT MARGARET ESTATE, PALLAMA AND AMBAKELLE SEED GARDEN

This experiment was commenced as a result of the recent findings through molecular studies that coconut in Sri Lanka has a narrow genetic base and mixing of exotic genetic materials especially from Southeast Asia and Pacific are necessary for further exploitation of hybrid vigour. Accordingly a crossing programme, involving three exotic coconut varieties; Rennel Island Tall (RIT), Tagnanan Tall (TAGT) and Malayan Red Dwarf (MRD) which were of Southeast Asian and the Pacific origin in various combinations with Sri Lanka Tall (SLT) and Sri Lanka Green Dwarf (SLGD) was launched for the development of new coconut cultivars. Pollen of these three varieties was regularly imported from Ivory Coast. Fifteen palms each of selected SLT palms at Margaret Estate were crossed with RIT, TAGT and MRD while twenty each SLGD at ISG were crossed with RIT and TAGT.

Table 9: Summary of the pollination programme at the Margaret Estate, Pallama

Cross	Total inflorescences pollinated	Buttons remained after 3 months	Total setting
SLT x RIT	170	3491	1161
SLT x TAGT	149	3420	994
SLT x MRD	185	3603	1239

Table 10: Summary of the pollination programme Sri Lankan Green Dwarf with exotic pollen at ISG

Pollination programme	Total inflorescences pollinated	Buttons remained after 3 months	Total setting
SLDG x RIT	140	1048	443
SLDG x TAGT	115	926	376

*C K Bandaranayake, M K Meegahakumbura, L Perera,
S A S Chandrasiri and M H L Padmasiri*

PROJECT: SCREENING OF COCONUT VARIETIES/CULTIVARS FOR MITE TOLERANCE AND DEVELOPMENT OF COCONUT HYBRIDS/CULTIVARS TOLERANT TO ACERIA MITE

1. Screening of coconut varieties/cultivars for mite tolerance

Screening of coconut varieties for *Aceria* mite tolerance was continued at BE and ISG and extended to evaluate the existing coconut cultivars at Thamanna Estate (TE), Puttalam and RE, where the experimental sites were naturally infested with *Aceria* mite.

At Tammenna Estate, Puttalam, three cultivars YDT, GDT and TT were screened for tolerance to mite attack. As there was a belief that the reddish colour form of tall coconut shows some tolerance to coconut mite, 20 such reddish colour palms (RT) selected from a nearby plantation were also included in this study. Total mite count per nut and damage assessment as a % of nut damaged in the 4 month old bunch at three times in 3 consecutive months and crop loss at harvest were recorded.

There was a significant difference ($P < 0.05$) in the total mite count among the three cultivars and the reddish colour form of tall studied for the first and second counts. The lowest mite count was observed for YDT (70.5 and 76.5 in first count and second count respectively) compared to other two cultivars and the reddish form (ranged between 213 - 535.5). A similar trend was observed for the damaged nut percentage. The lowest damage was recorded in YDT (9.1%) compared to other two cultivars and Reddish form (ranged between 19.79% - 77.79%). The results of the data analysis carried out for percentages crop loss due to mite damage at harvest, clearly indicated that the lowest mean crop loss was shown by YDT (5%) compared to between 15% to 20% in other cultivars tested. The study indicated that the mean total coconut mite population levels, damage initiation, and the crop loss due to mite damage were found to be the least in YDT and hence had the highest tolerance to coconut mite. The tolerance level decreased in the order of GDT, RT and TT respectively. The tolerance of YDT may be explained to be inherited from the dwarf yellow variety, which has shown greater degree of tolerance to mite attack.

Assessment of two more new crosses, YDSR, GDSR along with GDT at the variety observational plots at RE and a ordinary tall population in an adjacent block as a control was commenced this year for tolerance to mite. The block was naturally infested with mite but the incidence has been low. Data recording continued this year.

In the previous year it was shown that Yellow Dwarf (YD) and Gon thembili (GT) were more tolerant than Green Dwarf and local tall to coconut mite damage. Since there are some morphological differences within YD form, based on morphology of the palm the entire Yellow Dwarf population has been classified in to three groups. In order to find out whether there will be a difference in mite incidence among these three groups, an assessment was initiated using the index developed for assessing the mite incidence in palms.

L Perera, I R Wickramananda (CPD), W M Pushpakumara (CPD), N G Ruwantha (CPD), S. R. Sarathchandra (University of Ruhuna) and S. Mayadunne (CPD)

2) Development of coconut hybrids/cultivars for tolerance to mite

A crossing programme using local (SLT, GT and YD) and a few exotic varieties [Brazilian Green Dwarf (BGD), SR] was initiated in 2006 with dual objectives of identifying *Aceria* mite tolerant hybrids and exploiting hybrid vigour for yield. The crosses included GT x BGD (20 palms), SR x BGD (17 palms) and YD x GT (05 palms) at BE, SLT x BGD (20 palms) at PSG, BGD x GT (05 palms) at PRS and YD x GT (05 palms) at ISG. The pollination programme is expected to continue during the year 2007 and the resulting nuts will be nursery laid for evaluating the progeny at different sites.

S A C N Perera, S A S Chandrasiri and H M N B Hearth

2) Evaluating Gon thembili (GT) to assess its potential as a pure cultivar

GT is a local and less common coconut variety mostly found as single trees in home gardens and also amidst large plantations. GT has been observed to show a certain degree of tolerance to *Aceria* mite when it was screened for mite tolerance along with other varieties last year (see Annual Report 2005). This observation has led to the initiation of studies to assess the potential of GT to be recommended as a pure cultivar for highly mite infested areas. In view of this it was primarily required to assess the potential of GT as a nut and copra producer. Accordingly, a fruit component analysis was initiated while a collaborative study was commenced with Coconut Processing Research Division (CPRD) to assess per nut copra and DC content of GT in comparison with CRIC60. Studies were also extended to understand the nature of transmittance of GT characters to subsequent generations under open pollination conditions.

Nut counting in 52 GT palms at BE recorded an average of 41 nuts per palm for the latter half of 2006. Fruit component data [Fresh nut weight (FNW), Husked nut weight (HNW), Split nut weight (SNW) and Kernel weight (KW)] recorded as one nut per palm within the same 52 palms revealed promising results for GT (Table 8).

Table 8: *Fruit component data related to Gon Thembili*

	FNW(g)	HNW(g)	SNW(g)	KW(g)
Mean	1466	666.7	517.2	331.4
Std	311	120.8	75.4	52.39

CPRD conducted the analysis for copra outturn per nut which was revealed to vary from 161- 200 g/nut in 3 picks in GT while the same varied from 150-232 g/nut in CRIC60. The study will be continued in the year 2007 before arriving at any firm conclusion.

S A C N Perera, G K Ekanayake and C Yalagama (CPRD)

3) Development of a segregating population for mapping QTL governing tolerance to *Aceria* mite in coconut

Numerous immediate and medium term chemical and biological control measures for control of *Aceria* mite are been experimented at the Crop Protection Division (CPD). It is also worthwhile to test for long term strategies like identification of tolerant genotypes for building up of mite tolerant coconut populations as a persistent solution, with a view of combining research from different disciplines for a successful control of the mite. In this respect, approaches of molecular breeding provide useful tools for mapping QTL governing mite tolerance. Green Dwarf and many tall coconut varieties have been observed to be susceptible for *Aceria* mite while certain phenotypes of the variety Yellow Dwarf have been observed to be tolerant to the same. This morphological polymorphism in tolerance to mite among different varieties may be controlled genetically under the governance of quantitative trait loci and can be used to develop a segregating mapping population to map QTL governing mite tolerance. This research will contribute immensely to unravel the genetic basis of resistance/susceptibility among different varieties in coconut for ultimate marker assisted breeding for cultivars tolerant to coconut mite.

With the above mentioned background a CESS assisted project was commenced with the ultimate objective of tagging QTL for tolerance to *Aceria* mite. Under this project a hand pollination programme was started to produce a segregating population for tolerance to *Aceria* mite infestation. Nineteen highly mite tolerant Yellow Dwarf palms at field 10 of ISG were selected for crossing with pollen from a highly susceptible single tall parent (G72) located in field 11A at ISG. The progeny resulting from this cross is expected to segregate for the trait, tolerance to *Aceria* mite infestation. Two thousand five hundred and seventy eight female flowers belonging to 187 inflorescences were hand pollinated with a setting percentage of 25.5 % during the last 6 months in the year 2006.

S A C N Perera, L Perera and S A S Chandrasiri

PROJECT: COCONUT GENOME MAPPING (CESS ASSISTED PROJECT)

Three hundred and thirty nine (339) individuals of a segregating mapping population developed by crossing 26 Red Dwarf mother palms with a single Tall male parent were raised in the nursery. All the individuals from the said segregating population were genotyped with four microsatellite markers in order to confirm the parentage of the progeny for eliminating illegitimates from the mapping population. Subsequently, 298 of individuals were selected as legitimate progeny of the cross performed.

In addition, morphological parameters namely, the rate of leaf production, girth and the height of seedlings were recorded at 6 monthly intervals. The seedlings are now ready for field planting which will be done in *Yala* season in 2007. Genotyping with microsatellite markers will be continued in the year 2007 and it is expected to get the mapping population genotyped with microsatellite markers and Diversity Array markers in order to obtain a high density linkage map.

*C K Bandaranayake, S A C N Perera, L Perera,
65 W B S Fernando, A Fernando,*

PROJECT: COLLECTION CONSERVATION AND EVALUATION OF COCONUT GERMPLASM

ENRICHMENT OF COCONUT GERMPLASM

Importation of Coconut Germplasm (CESS Funded)

During the year, enrichment of coconut germplasm with exotic varieties was continued and 80 coconut seedlings comprising 12 Gezelle Peninsula tall, 6 PNG brown dwarf, 3 Malayan Red Dwarf, 11 Malayan Yellow Dwarf, 14 Tenga Tall, 17 Tagnanan Tall, 8 West African Tall, 6 Vanuatu Tall, 3 Catigan Green Dwarf, brought as embryos from Papua New Guinea and Ivory Coast and *in-vitro* raised at the Tissue Culture Division were field planted at BE. Attempts made to import Hainan Tall, which is a cold tolerant coconut variety in China failed this year.

M K Meegahakumbura, L Perera and R B Attanayake

EVALUATION OF CONSERVED COCONUT GERMPLASM

Collection and conservation of coconut biodiversity within the country

All the existing *ex-situ* field gene-banks (BE, PRS, Margaret estate, Lenawa, Raddegoda and Gonagolla) were maintained successfully. A new *ex-situ* gene bank was established at Middeniya Regional Research Centre this year and 304 seedlings from three new collections; Rumassala, Kurunegala and Deegawapi were field planted there. During the year 86 seedlings from new tall accession; Muthiyangana and 30 seedlings of Cameroon Red Dwarf also were field planted at the *ex-situ* gene bank at Margaret Estate.

*L Perera, C K Bandaranayake, S A C N Perera, H D M A C Dissanayake,
G K Ekanayake, H M N B Herath and R B Attanayake*

Multiplication of indigenous coconut varieties

A pollination program was in progress to multiply indigenous coconut varieties to establish at the new field gene bank for conservation of indigenous coconut varieties at Margaret estate. During the year 246 seedlings belonging to 12 indigenous coconut forms [Red Dwarf - 41, Ran thembili - 95, Gon thembili - 29, Bodiri - 68, Kamandala - 5, Porapol - 8] resulting from previous year's pollination were field planted at this new genebank at Margaret Estate.

H D M A C Dissanayake, L Perera and G K Ekanayake

Collection, conservation and evaluation of coconut biodiversity in the Southern Province (CESS assisted Project)

Collection and compilation of data related to stem, leaf, inflorescence and fruit morphology of the newly identified Southern coconut phenotypes Bothal thembili, Juwan pol, Ran pol and Murusi were continued for the second year. Comparative data for 6 already known

coconut forms, namely, Sri Lanka Tall, Sri Lanka Green Dwarf, San Ramon, King coconut, Bodiri and Sri Lanka Brown Dwarf have been collected simultaneously for determining the inter-phenotypic diversity of different coconut forms (Table 9).

Table 9: *A summary of the data collected on coconut biodiversity collected from Unawatuna area during 2006.*

Phenotype	Stem morphology (no.of palms)	Leaf morphology (No. of leaves)	Inflorescence Morphology (No. of inflorescences)	Fruit Morphology (No. of nuts)
Ran pol	9	17	50	182
Juwan	7	21	56	160
Bothal thembili	7	30	57	156
Murusi	9	23	46	124
SLT	7	14	48	52
King coconut	7	12	40	78
Green Dwarf	9	18	38	72
San Ramon	7	16	40	65
Brown Dwarf	7	20	46	136
Bodiri	7	7	25	35

The data collection will be completed in the year 2007 and molecular studies will be carried out for understanding the genetic diversity of the newly identified coconut phenotypes.

The self pollinating programme for purifying and *ex-situ* conservation of new phenotypes was terminated this year. Two hundred and twenty seven selfed seed nuts belonging to phenotypes Ran pol, Bothal thembili, Rath Gon thembili, Murusi and Juwan coconuts and 245 open pollinated nuts of the same phenotypes were nursery laid. During the year 27 Murusi seedlings were field planted at Margaret Estate.

*G K Ekanayake (Full time M.Phil study), C K Bandaranayake,
J M D T Everard [Deputy Director (Research)] and S A C N Perera*

CHARACTERIZATION OF COCONUT GERMPLASM

Characterization and evaluation of indigenous Thembili germplasm (1996)

The trials at Margaret Estate and Raddegoda Estate are progressing satisfactorily.

C K Bandaranayake and R B Attanayake

Evaluation of morphological differences and yielding ability of nut colour based phenotypes of Sri Lanka Tall Coconuts

The colour of the nut in variety *typica*, form *typica* shows a continuous variation ranging from green to brownish red (*rathi*). The growers' perception is that *rathi* seedlings are more vigorous and ultimately become higher yielders than the phenotype with green nuts. A study was conducted to evaluate and compare the nut and copra yield, seedling vigour, and stem and leaf morphology of phenotypic groups classified as green, *rathi* and intermediate coloured nuts. Secondary data for nut yield over 21 years, husked nut weight of 3 nuts per palm collected over a year in 30 palms from each classified group were analyzed. All the ninety adult palms have been grown at field no 4 of ISG and the same 30 palms were used for recording stem and leaf morphology. Furthermore, data for seedling girth, height and leaf number were recorded in sample sizes of 30 palms each for *rathi* and green phenotypes.

The nut and copra yield of the three phenotypes did not reveal a significant difference over the years indicating that all the phenotypes are similar in their capacity for nuts and copra production. *Rathi* and intermediate palms are smaller than green palms with respect to the stem girth and in addition intermediate palms produce smaller crowns compared to green or *rathi* phenotypes as indicated by the lengths of rachis. The study revealed that the *rathi* seedlings are more vigorous as indicated by the thicker stem compared to the green coloured seedlings, but does not show any difference in nut and copra yield among the different nut colour phenotypes of variety *typica*, form *typica* when grown in highly favourable soils for growing coconut.

S A C N Perera and W M Kumarasinghe (University of Wayamba)

OUTSIDE FUNDED PROJECTS

(A) Diagnosis of Pathogens using molecular tools (CESS Funded)

The pathogen diagnosis study on tapering disorders was extended this year to test the phytoplasma hypothesis for the leaf rot disease which showed symptoms similar to Kerala Wilt in India. DNA extracted from trunk shaving samples of leaf rot disease affected palms gave positive PCR products with phytoplasma specific primers. Sequencing of the PCR product for the confirmation of the result is to be carried out in 2007.

L Perera, S R M Ranaweera (University of Wayamba) and W B S Fernando

(B) Increase of CRIC65 seed nut production at the ISG (CESS Funded)

Upgrading of the ISG was continued this year too. Field 12B which had a high density tall stand was converted into a dwarf-tall mixed field this year by uprooting every alternative row of tall palms in there and by planting 460 dwarf green seedlings in the vacant places. Dwarf seedlings planted last year in field 12A were maintained properly during the year.

L Perera and S A S Chandrasiri

(C) Genetic variation and identification of varieties suitable for tender nut (CESS Funded)

The survey which was started in 2005 to identify potential varieties for beverage purposes was completed during the year after evaluating potential varieties within coconut triangle and Southern province. Several coconut phenotypes were identified as highly suitable for promoting to be used as beverage purposes apart from the already popular variety king coconut. Seasonality has been observed in many of the profusely bearing phenotypes while the number of nuts also varies depending on the season. Table 10 summarizes the data gathered during the year.

S A C N Perera, J M D T Everard [Deputy Director (Research)] and G K Ekanayake

(D) Establishment of Pallama Seed Garden (PSG) (CESS Funded)

Establishment of PSG for mass production of CRISL98 was continued. Selfing of San Ramon at PRS and Andigama Farm, Giriulla was continued. Pollination programme was initiated in June this year at field 4 of the PSG with selected 50 Tall palms to produce required Tall x Tall seedlings for planting field 4 of the seed garden. Table 11 summaries the pollination programmes conducted during the year 2006.

*C K Bandaranayake, M K Meegahakumbura,
L Perera and M H L Padmasiri*

Table 10: Phenotypes identified and their suitability for beverage purposes

Phenotype	Locality	Volume of nut water	Taste	Seasonality	No. of nuts/bunch
King coconut	Scattered	300-350	Good	Seasonal	10-30
Bothal thembili	Galle	350-400	Marginal	No	4-10
Green Dwarf	Scattered	250-300	Good	Seasonal	10-25
Yellow Dwarf	Scattered	400-500	Good	No	10-25
Red Dwarf	Scattered	350-400	Good	No	15-30
Brown Dwarf	Rare	400-500	Very good	Seasonal	10-30
Bodiri	South	200-250	Good	Seasonal	10-40
Murusi	Galle	250-300	Very good	Seasonal	8-20
Brazilian Green Dwarf	CRI	300-350	Very good	Seasonal	10-30
Cameroon Red Dwarf	CRI	300-350	Good	Seasonal	12-30
Dothalu	Galle	225-275	Very good	Seasonal	15-40
Juwan	Galle	225-275	Very good	No	10-30

Table 11: Summary of the pollination programmes conducted during the year 2006 under the project Pallama Seed Garden establishment.

Location	Cross	Total inflorescence pollinated	Total female flowers remained	Total setting
PRS (19 palms)	SR x SR	318	6192	1239
Andigama farm, Giriulla. (26 palms)	SR x SR	331	6197	974
PSG Field 4 (50 palms)	T x T	374	4886	2082

(E) Establishment of Maduru-Oya seed garden (MOSG)

Two hundred and forty three open pollinated seedlings of ISG origin belonging to 18 half-sib families were field planted at Maduru-Oya Seed Garden (MOSG) this year.

L Perera and M K Meegahakumbura

(F) Establishment of a seed garden for Kapruwana (CESS Funded)

During the year expression of interest were called from private and government sector organization to join hands with CRI to establish a new seed garden for mass production of Kapruwana coconut cultivar. Several responses were received and this activity is to be continued next year.

L Perera and S A C N Perera

(G) Establishment of Seed Certification Unit (CESS Funded)

Commencement of the Seedling Certification is the key activity under the services and development functions of the division this year. Seedling certification was commenced initially to certify only polybagged seedlings of cultivars CRIC60 and CRIC65 only. During the year, eleven estates were selected as plus palm estates by the unit for the supply of seed nuts for the National Replanting Programme (NRP). Registration was provided for five private coconut nurseries.

R Jayathilake and L Perera

REPORT OF THE SOILS AND PLANT NUTRITION DIVISION

Head - N.A. Tennakoon, Ph D

1. GENERAL

The Research programmer of the Division was aimed at refining technology on soil nutrient management giving emphasis on application of inorganic fertilizer and locally available organic sources such as animal and green manure, while maintaining soil quality and nutrient levels of different types of coconut growing soils. Studies also commenced to evaluate the fertility levels in degraded coconut soils in different Agro-Ecological Regions. Further particular interest was placed on developing irrigation/fustigation techniques for coconut to overcome drought damage.

During the year, the Division maintained 20 on-going field experiments under 9 projects. Three new field experiments and one green house experiment were commenced during the year. The Division has also conducted few basic studies to compliment the ongoing major experiments. The total research expenditure for research and maintenance was Rs. 3,248,000/- and Rs.1, 061,000.00 respectively. A sum of Rs. 1,995,000/- was also received from coconut CESS Fund.

The experiment on site specific fertilizer recommendation at Mangala Eliya (DL3, Borupan soil series - S2), showed significant increase in 85% nut yield ($p \leq 0.001$) from the palms receiving 1400 g Urea, 1050 g Imported Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (Treatment 4) over the control (no fertilizer) and 28% nut yield increase in the recommended fertilizer (T2 - 800 g Urea, 600 g Imported Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite) treated palms over the control. Increase of Urea by 600 g, Imported Rock Phosphate by 670 g, Muriate of Potash by 1200 g and Dolomite by 750 g (T4) has shown the highest nut yield (50%) compared to the recommended dosage (T2). The same experiment at Sirigampola (IL1 Madampe soil series - S1), showed 70% increase in nut yield ($p \leq 0.001$) from the palms receiving 1700 g Urea, 1905 g Eppawela Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over the control (no fertilizer) and 23% increase in nut yield was observed in the recommended fertilizer dosage treated palms (T2 800 g Urea, 900 g Eppawela Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite) over the control. Increase in Urea by 900 g, Eppawela Rock Phosphate by 1005 g, Muriate of Potash by 1800 g and Dolomite by 1125 g (T5) has shown the highest nut yield (38%) compared to the recommended dosage (T2). The same experiment at Kobeigane (IL1 Wariyapola soil series - S3) 73% nut yield increase was observed significantly ($p \leq 0.05$) from the palms receiving 1400 g Urea, 1570 g Eppawela Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (Treatment 4) over the control (no fertilizer) and 19% nut yield increase was observed in the recommended fertilizer treated palms (T2) over the control. This year i.e. four years after fertilizer application, these nut yield increases have shown particularly in Borupan, Madampe and Wariyapola series soil in the Dry, Wet and Intermediate zones respectively.

The experiment on different sources of phosphate i.e. Triple Super Phosphate, Imported Rock Phosphate and Eppawela Rock Phosphate revealed that no significant difference in nut yield i.e. 15 years after the establishment of the experiment at Ratmalagara Estate (IL1). Therefore the recommendation of Eppawela Rock Phosphate as a source of P

especially for Wet and Intermediate zones can be continued and this will lead to a substantial savings of foreign exchange.

Experiment on comparison of the efficiency of organic and green manure against inorganic fertilizer (APM-W) showed 52% significant ($p \leq 0.05$) increase in the nut yield of palms receiving poultry manure compared to the control (no fertilizer). The yield increase by inorganic fertilizer over the control (no fertilizer) was 24%. Nut yield of poultry manure treated palms increased by 23% over inorganic fertilizer treated palms. The nut yield increase in other organic sources such as cattle manure, goat manure and green manure - gliricidia was 43%, 33% and 22% respectively over the control. The initiation of female flowers was also significantly higher ($p \leq 0.001$) in poultry manure treated palms than that of control (no fertilizer) as well as inorganic fertilizer treated palms. Results indicated that the application of organic manures such as poultry manure, cattle manure, goat manure etc. were more economically beneficial than inorganic fertilizers as reported in the previous years.

The experiments conducted for the determination of soil fertility decline in coconut lands revealed that the major nutrients such as N, P, K and Mg have been depleted by 34%, 138%, 200% and 105% respectively in coconut grown soils of Dry zone compared to adjacent virgin soils. Same experiment at Ratmalagara Estate revealed that major nutrients such as N, P, K and Mg were depleted by 394%, 52%, 64% and 167% respectively in coconut grown soils of Intermediate zone compared to adjacent virgin soil. The microbiological parameters were also significantly reduced in coconut grown soils of both agro ecological zones. This study clearly proves that long-term cultivation of coconut as a monocrop without proper soil management practices drastically reduce soil fertility, quality and biological properties regardless of the region.

As service functions, the Division provided Differential Fertilizer Recommendation (DFR) to 120 growers covering 1300 ha during the year. For quality testing, 310 inorganic fertilizer, 110 organic manure and 725 coir pith samples were analyzed. In addition, soil survey and land suitability tests were completed for 40 growers covering a total extent of 2020 ha.

2. RESEARCH PROJECTS

PROJECT 6.0: SUBSTITUTION OF LOW COST PHOSPHATE (ERP) IN PLACE OF IMPORTED ROCK PHOSPHATE FOR YOUNG COCONUT PALMS IN DIFFERENT AGRO ECOLOGICAL REGIONS

Experiment 6.0.1: *Effect of different phosphate sources on the performance of coconut seedlings (1991)*

This experiment was a Randomized Block Design with 3 replicates and 6 palms per plot. Experiment was established in 1991, T x T seedlings was planted on Andigama series soils (Red Yellow Podzolic) at Ratmalagara Estate in IL1 agro ecological region. The site falls into land suitability class S4.

Treatments are given in Table 1.

Table 1: *The sources of P and the rates of application*

Treatments	Rate of application g/palm/yr
T1 - TSP (46% P ₂ O ₅)	350
T2 - IRP (27.5% P ₂ O ₅)	600
T3 - ERP (30% P ₂ O ₅)	600
T4 -Control (No P source)	0

Basal application - Urea	800 g/palm/yr
Muriate of potash	1600 g/palm/yr
Dolomite	1000 g/palm/yr

The leaf samples from 14th frond of treated palms were taken in May 2006. Fertilizer application was carried out in October. Nut yield data from October 2005 to September 2006 showed significant differences among the treatments (Table 2).

Table 2: *Nut yield of the experiment*

Treatment levels	Nut yield	
	2002 October to 2005 September Cumulative (per palm)	2005 October to 2006 September (per palm per year)
T1 - TSP	146	40
T2 - IRP	141	63
T3 - ERP	137	62
T4- Control (No P sources)	118	57
Level of significance	ns	*
LSD (p ≤ 0.05)	-	16.650

The leaf nutrient levels i.e. N and P have shown significant differences ($p \leq 0.01$) among the treatments. Even though potassium levels were not significant, the K levels of the palms were above the critical levels ($K > 1.2\%$). Leaf magnesium levels of the treated palms were below the critical levels ($Mg > 0.25\%$). The magnesium levels of the palms were increased in this year compared to the last year (Table 3).

Table 3: Nutrient concentration in the 14th frond

Treatment levels	N%	P%	K%	Mg%
T1 - TSP	1.96	0.16	1.46	0.19
T2 - IRP	2.12	0.15	1.51	0.20
T3 - ERP	2.01	0.15	1.42	0.23
T4 - Control (No P source)	2.27	0.12	1.52	0.24
Level of significance	**	**	ns	ns
LSD ($p \leq 0.05$)	0.187	0.007	-	-

Even though it has shown significant difference P content of the 14th leaf between TSP and other treatments, it was clearly proven that there was no significant difference of P content of the leaves among IRP and ERP treated palms as well as nut yield. Therefore application of ERP is sufficient to supplement phosphate requirement in the Wet and Intermediate zone coconut soils and this will lead to a substantial savings of foreign exchange

*N A Tennakoon, C P A Kurundukumbura,
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Experiment 6.0.2: Effect of different phosphate sources on the performance of coconut seedlings in Southern soils – 2005 (CESS Funded)

The experiment was a Randomized Block Design with 3 replicates and 6 palms per plot. It was established in December 2005 by planting TxSR seedlings on Katuwana soil series (Reddish Brown Latosols) at Middeniya sub station in IL1 Agro Ecological Region. The site falls into the land suitability class S2 (Potential nut yields is 12,500 - 15,000 nuts/ha/yr). Treatments are given in Table 4.

Table 4: Treatments of the experiment

Treatment Levels	6 m	1 yr	1 1/2 yrs	2 yrs	2 ½ yrs	3 yrs	3 1/2 yrs	4 yrs up to bearing	After bearing
T1- Control	-	-	-	-	-	-	-	-	-
T2 – ERP	340	405	405	540	540	675	675	810	900
T3 – IRP	225	270	270	360	360	450	450	540	600
T4 – HERP	170	200	200	275	275	340	340	405	450
T5 - TSP	145	175	175	235	235	290	290	350	390

Basal Dose

-

Urea, Muriate of Potash and Dolomite as per recommendation

Rates up to bearing - g/palm/6 months

The 1st and 2nd (i.e. at the age of 6 months and 1 year) treatment applications were completed in June and December 2006 and preliminary soil and leaf samples were collected before the application of treatments. Leaf samples were also collected in December 2006 before the 2nd treatment application. The vegetative growth measurements i.e. girth of stem, number of fronds, height of seedlings and leaf area were also recorded twice a year before the application of treatments. The vegetative growth measurements have not shown significant differences among the treatments within one year period.

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PROJECT 7.0: FORMULATION OF FERTILIZER MIXTURES FOR YOUNG PALMS, TAPPING PALMS AND KING COCONUT PALMS

Experiment 7.0.1: Assessment of the effect of N, K and Mg on the performance of coconut seedlings (1991)

This experiment was established in 1991 with T x T seedlings planted on Andigama series soil at Ratmalagara Estate. The experiment was 3 x 3 x 3 N, K Mg factorial experimental design.

The nut yield didn't show any significant differences for the main treatments as well as interactions from the beginning of the experiment. The leaf nutrient levels also showed the same results. Therefore it was decided to terminate this experiment according to the decision made at the Research Committee Meeting held in July, 2006.

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PROJECT 7.1: IMPROVEMENT OF DIFFERENTIAL FERTILIZER RECOMMENDATION (DFR) BASED ON NUTRIENT STATUS OF LEAF AND SOIL

Experiment 7.1.2: Evaluation of the productivity of coconut palms in response to high doses of chemical fertilizer and development of criteria for Differential Fertilizer Recommendation (DFR)

The objectives of this experiment were to test the response of coconut palms in different land suitability classes to different fertilizer doses that are higher than the generally recommended dose and in relation to data on soil, plant and fertilizer rates to develop recommendations for coconut palms in high potential lands.

This experiment was a Randomized Block Design with 3 replicates and six palms per plot. It was established at the following locations.

Expt. No	Location	Agro ecological Region	Soil series	Year of commencement	Land suitability Class
7.1.2.1	Mangala-eliya	DL1	Borupan series	2000	S2
7.1.2.2	Naiwala	WL3	Boralu series	2002	S4
7.1.2.3	Kobeigana	IL1	Wariyapola series	2002	S3
7.1.2.4	Sirigampola	IL1	Madampe series	2002	S1
7.1.2.5	Wellawa	IL1	Kurunegala series	2003	S2

The treatments for all sites are given in Table 5.

Table 5: *Treatment combinations of the experiment (g/palm/yr)*

Treatments	Urea	IRP/ERP	MOP	Dolomite
T1	0	0	0	0
T2	800	600 / 900	1600	1000
T3	1100	825/1235	2200	1375
T4	1400	1050/1570	2800	1750
T5	1700	1225/1905	3400	2125

7.1.2.1: Mangala-eliya site

The nut yield of the experiment at Mangala-eliya site is given in Table 6.

Table 6: *The nut yield of Mangala-eliya site*

Treatment	Cumulative nut yield 2001 Sept. 2005 Aug.	Nut yield (palm/year) 2005 Sept. to 2006 Oct.
T1	372	59
T2	460	80
T3	455	83
T4	465	120
T5	445	102
Level of Significance	$p \leq 0.05$ in (2003 & 2004) & $p \leq 0.01$ (2005)	$P \leq 0.001$
LSD ($P \leq 0.050$)	13 (2003 & 2004), 15 (2005)	15

A significant increase ($p \leq 0.001$) in nut yield (85%) was observed from those palms receiving 1400 g urea, 1050 g Imported Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (T4) over control (no fertilizer) and 28% nut yield increase was observed in the recommended fertilizer treated palms (T2) - 800 g Urea, 600 g Imported Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite over control.

Increase of urea by 600 g, Imported Rock Phosphate by 450 g, Muriate of Potash by 1200 g and Dolomite by 750 g have shown the highest nut yield or 50% increase in yield compared to the recommended dosage fertilizer (T2). This year i.e. 6 years after fertilizer application, nut yield increase was shown particularly in Borupan series soil (S2) in the Dry zone where experiment is located. It was clearly shown that coconut plantations at highly

fertile soils i.e. S2, the supply of nutrients have to be increased by 1.5 to 2 times compared with general recommendation.

The leaf sampling was completed in April 2006. All the leaf nutrients were in the sufficiency range (N \geq 1.9%, P \geq 0.11%, K \geq 1.2 % Mg \geq 0.25%). The K levels were increased in this year compared to the last year (Table 7).

Table 7: *Leaf nutrient levels of the 14th leaf at Mangala eliya site*

Treatments	N%	P%	K%	Mg%
T1	1.98	0.13	1.28	0.27
T2	2.08	0.13	1.34	0.28
T3	2.03	0.13	1.41	0.29
T4	2.04	0.13	1.36	0.30
T5	2.02	0.13	1.40	0.32
Level of Significance	ns	ns	ns	ns

Two soil samples were collected in June 2006. The soil nutrient values of the treatment applied soils were given in Table 8.

Only K levels and electrical conductivity of the soils have shown significant difference ($p \leq 0.05$) at the depth of 0 - 20 cm among the treatments. The treatment application was completed in July 2006.

Table 8: *Soil nutrient levels at Mangala-eliya site (Soil depth at 0 - 20 cm)*

Treatment	pH (1:5)	EC ($\mu\text{s}/\text{cm}$)	N (mg/kg)	P (mg/kg)	K(meq/100g)	Mg(meq/100g)	Ca(meq/100g)	Na(meq/100g)
T1	6.50	35.45	139.97	192	0.15	0.73	1.09	0.07
T2	6.42	52.95	127.69	237	0.24	0.63	1.16	0.07
T3	6.38	48.28	116.63	203	0.26	0.77	1.81	0.07
T4	6.68	54.00	178.03	332	0.30	0.91	2.25	0.06
T5	6.66	53.28	205.03	251	0.33	0.75	1.80	0.07
Level of Significance	ns	*	ns	ns	*		ns	
LSD ($p \leq 0.05$)	-	11.004	-	-	0.114	-	-	-

Experiment 7.1.2.2 - Naiwala

A significant increase ($p \leq 0.001$) in nut yield (39%) was observed in palms receiving 1700 g Urea, 1905 g Eppawela Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over the control (no fertilizer) and 12% increase in nut yield was observed over recommended dose of fertilizer applied palms (T2 - Urea 800 g, Eppawela Rock Phosphate 900 g, Muriate of Potash 1600 g and Dolomite 1000 g) 3 years after improvement of K fertilizer treatment. The female flower number also significantly increased in highest fertilizer treatment applied (T5) palms compared to no fertilizer (T1 - Control) palms (Table 9).

Table 9: *Nut yield and female flower products at Naiwala site*

Treatment	Nut yield palm/year			Female flowers palm/year		
	2003 Nov. to 2004 Oct.	2004 Nov. to 2005 Oct.	2005 Nov. to 2006 Oct.	2003 Nov. to 2004 Oct.	2004 Nov. to 2005 Oct.	2005 Nov. to 2006 Oct.
T1	4	27	71	129	75	127
T2	7	49	88	122	69	169
T3	5	37	94	118	63	172
T4	6	48	96	119	65	174
T5	5	50	99	106	59	186
Level of significant	ns	**	***	ns	ns	***
LSD ($p \leq 0.05$)	-	8.102	8.580	-	-	20.252

The leaf samples were collected in October 2006. In the experiment leaf K and Mg nutrient levels have shown significant difference among the treatments. But N and P have not shown significant differences among the treatments (Table 10). In general leaf nutrient levels (N, K and Mg) are below the critical levels except P.

Table 10: *Leaf nutrient levels of the Naiwala Site*

Treatment	N %	P %	K %	Mg
T1	1.82	0.14	0.45	0.29
T2	1.81	0.13	0.86	0.18
T3	1.79	0.12	1.13	0.16
T4	1.81	0.12	1.35	0.12
T5	1.79	0.12	1.47	0.11
Level of significance	ns	ns	***	***
LSD ($p \leq 0.050$)	-	-	0.269	0.052

The soil samples were collected in September 2006 and analysis are in progress. Treatments were applied in November 2006, 3rd year after establishment of the experiment.

Experiment 7.1.2.3 - Kobeigane

The same experiment site at Kobeigane has shown 73% increase in nut yield ($p \leq 0.01$) from the palms receiving 1400 g Urea, 1570 g Eppawela Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (Treatment 4) over the control (no fertilizer) and 19% nut yield increase in the treatment receiving recommended dosage of fertilizer (T2) over the control. This year i.e. four years after fertilizer application, significant yield increase has shown particularly in Wariyapola series soil in the Intermediate zone (Table 11).

The leaf and soil samples were collected in December 2006 and analyses are in progress. The 3rd year fertilizer application was completed in December 2006.

Table 11: *Nut yield of the Kobeigane experimental site*

Treatment	Nut yield palm/year		
	2003 November - 2004 October	2004 November - 2005 October	2005 November - 2006 October
T1	70	46	82
T2	72	51	96
T3	76	70	98
T4	82	76	142
T5	78	65	140
Level of significant	ns	**	*
LSD ($p \leq 0.05$)	-	15.91	42.42

Experiment 7.1.2.4 - Sirigampola

The site at Sirigampola has shown 70% significant increase ($p \leq 0.01$) in nut yield from the palms receiving 1700 g Urea, 1905 g Eppawela Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over the control (no fertilizer) and 23% nut yield increase in the treatment received recommended fertilizer (Treatment 2) over the control (Table 12).

Table 12: *Nut yield of the Sirigampola Site*

Treatment	Nut yield palm/year		
	2003 November - 2004 October	2004 November - 2005 October	2005 November - 2006 October
T1	72	41	73
T2	75	45	90
T3	74	54	99
T4	74	55	107
T5	81	65	124
Level of significant	ns	**	***
LSD ($p \leq 0.05$)	-	14.42	13.10

The leaf samples were collected in August. Leaf nutrient analysis showed the leaf K & Mg have been increased with K & Mg treatments (significance at $p \leq 0.05$) in this year (Table 13). Soil samples were collected in October 2006 and the analysis is in progress. Treatment application was done in November 2006.

Table 13: *Nutrient level of the 14th frond at Sirigampola site*

Treatment	N %	P %	K %	Mg %
T1	2.13	0.14	0.62	0.23
T2	2.16	0.14	1.20	0.24
T3	2.17	0.14	1.20	0.25
T4	2.24	0.14	1.38	0.26
T5	2.35	0.14	1.60	0.27
Level of significant	ns	ns	*	*
LSD ($p \leq 0.05$)	-	-	0.388	0.060

Experiment 7.1.2.5 - Wellawa

The 3rd fertilizer application was carried out in December 2006. The nut yield has not shown significant difference among the treatment in this year (Table 14).

Table 14: *Nut yield of the experiment at Wellawa Site*

Treatment	Nut yield palm/year		
	2003 November - 2004 October	2004 November - 2005 October	2005 November - 2006 October
T1	72	46	44
T2	75	47	45
T3	74	45	48
T4	74	42	52
T5	81	43	49
Level of significant	ns	ns	ns

Leaf and soil samples were collected in September 2006 and the analyses are in progress.

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PROJECT 7.2: STUDIES ON THE ROLE OF NUTRIENTS IN THE PRODUCTIVITY OF THE COCONUT PALM

Experiment 7.2.2: Quantification of the removal of some nutrients by the coconut palm

The aim of this experiment was to quantify the removal of some micronutrients from coconut palms growing in moderately suitable (S4) and highly suitable (S1) land classes.

The experiment on land suitability class S4 was commenced in 2005 in a field containing Boralu series soil at Bandirippuwa Estate. Ten T x T palms, which were 20 years old, were randomly selected as replicates for further experiments. The number and the weight of each component harvested and removed from the palm was determined at monthly intervals. The vegetative and yield components removed from the palm in each month from October, 2005 were collected and dry weights were determined. The components were analyzed for N, P, K, Ca, Mg, S, Cl, B, Fe, Cu, Zn, Mn. The full year data are given in Tables 15, 16 and 17.

This data could be used in determining the pattern and the rate of micronutrient as well as macronutrient removal of the coconut palm which is belongs to S4 land suitability class.

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Table 15: *Nutrients removed by each component of the palm in one year period (October 2005 to September 2006)*

	N	P	K	Mg	Ca	Na	Cl	S	B	Cu	Fe	Mn	Zn
	<-----g----->												
Nut													
Shell	26.11	10.01	114.15	3.88	2.73	13.46	9.58	0.24	0.03	0.36	2.92	0.06	0.20
Kernel	179.09	31.27	101.11	13.93	1.51	10.16	9.25	4.15	0.08	0.15	1.06	0.36	0.25
Husk	61.58	14.53	607.10	27.89	31.69	19.30	321.68	0.64	0.42	0.38	2.01	0.47	0.35
Nut water	4.28	1.41	29.76	1.31	3.04	0.80	0.05	0.00	0.12	0.01	0.06	0.05	0.01
Sub Total	271.06	57.23	852.12	47.00	38.97	43.72	340.57	5.03	0.65	0.89	6.05	0.94	0.81
Inflorescence													
Spadix & Spike	25.13	5.03	120.22	15.69	11.36	13.94	59.11	0.38	0.06	0.05	0.27	0.07	0.06
Matalu	1.77	0.21	0.75	0.33	0.64	0.35	0.21	0.00	0.00	0.01	0.34	0.01	0.01
Spath	12.89	1.79	13.04	4.85	9.26	1.51	1.18	0.24	0.14	0.04	0.26	0.11	0.03
Bract	2.47	0.45	11.72	0.55	0.69	0.69	6.93	0.01	0.01	0.01	0.05	0.01	0.01
Immature nuts	3.15	0.56	7.55	0.46	0.67	0.12	3.06		0.01	0.00	0.09	0.01	0.01
Sub Total	45.40	8.04	153.28	21.88	22.63	16.61	70.50	0.63	0.21	0.11	1.00	0.21	0.11
Fronde													
Ekel	15.81	4.23	27.15	14.21	16.67	6.52	7.08	0.75	0.04	0.04	1.07	0.65	0.12
Leaflet	60.14	10.80	48.84	20.64	144.19	10.69	64.72	15.12	0.11	0.03	1.79	2.43	0.28
Rachis	31.39	15.20	166.55	39.69	103.73	69.58	80.11	6.06	0.16	0.12	0.78	0.74	0.40
Sub Total	107.33	30.23	242.54	74.54	264.60	86.78	151.92	21.93	0.31	0.20	3.64	3.82	0.82
Grand Total	423.79	95.50	1247.94	143.42	326.19	147.11	562.99	27.60	1.18	1.20	10.69	4.96	1.72

Table 16: *Average fronds and nuts removal of 10 palms from October 2005 to September 2006*

	Oct/05	Nov/05	Dec/05	Jan/06.	Feb/06	March/06	April/06	May/06	June/06	July/06	Aug/06	Sept/06
Fronds	2	0.6	0	0	0.2	0.4	3.3	3.1	0.5	0	0.6	0.5
Nuts	4	3.4	4.1	3.8	6.7	8.8	10.6	10.9	13.1	7.9	12.2	7.1

Table 17: *Nutrient levels of the 14th frond of 10 experimental palms*

Palm No.	N	P	K	Mg	Ca	Na	Fe	Mn	Cu	Zn	Cl	B
	< ----- % ----- >						< ----- mg/kg ----- >					
1	2.00	0.113	1.48	0.16	0.38	0.08	87.7	91.8	5.74	20.05	3.55	8.81
2	1.96	0.130	1.52	0.20	0.35	0.13	105.1	93.3	6.86	21.60	4.44	7.59
3	2.24	0.141	1.69	0.22	0.36	0.14	91.2	91.8	6.90	20.97	4.31	14.73
4	2.14	0.130	1.46	0.22	0.37	0.07	84.8	89.8	6.42	15.14	5.33	9.28
5	2.10	0.136	1.37	0.15	0.30	0.08	122.0	90.4	6.98	193.51	3.55	9.72
6	1.96	0.109	1.15	0.20	0.40	0.10	86.3	74.2	7.52	24.14	3.11	7.14
7	2.00	0.136	1.60	0.21	0.36	0.08	98.3	93.1	7.30	20.33	4.00	9.72
8	2.17	0.141	1.53	0.20	0.38	0.11	80.5	110.8	6.96	26.69	4.44	11.23
9	2.00	0.146	1.41	0.18	0.41	0.09	81.8	128.7	6.63	26.36	4.44	6.53
10	1.86	0.131	1.38	0.27	0.46	0.08	78.6	106.1	7.99	26.04	4.44	10.02
\bar{X}	2.04	0.131	1.46	0.20	0.38	0.10	91.6	97.0	6.93	39.48	4.16	9.48

PROJECT 9.0: DEVELOPMENT OF IMPROVED FERTILIZER APPLICATION TECHNIQUES FOR COCONUT TO IMPROVE EFFICIENCY OF UPTAKE AND TO MINIMIZE COST

Experiment 9.0.2: Studies on different methods of kieserite application with NPK mixtures to coconut palms for minimizing K and Mg interaction

The objective of this experiment was to find the best method of kieserite application with NPK mixtures for correcting Mg deficiency of coconut palms efficiently whilst minimizing K and Mg interaction. The experiment, on a Randomized Block (Complete) Design with single palm treatment with four treatments, four palms per block, and 3 replicates per group with six groups was established in 2002 at Bandirippuwa Estate.

Location	Agro-ecological Region	Soil type	Land suitability class
Bandirippuwa Estate	IL1	Gravel (Boralu series)	S4

Treatment combinations are given in Table 18.

Table 18: Treatment combinations of the experiment

	Application rate (palm/year)
T1	3 kg APM (MOP 1600 g + Urea 800 g + ERP 600 g)
T2	3 kg APM + 1 kg Kieserite
T3	3 kg APM + 1 kg Kieserite (6 months later)
T4	Urea 800 g + ERP 600 g + MOP 1600 g Kieserite 1 kg } ½ circle

No. of nuts as well as no. of female flowers of treatment palms have not shown significant difference among the treatments during the period of October 2005 to September 2006 (Table 19). Nevertheless no. of nuts and no. of female flowers were increased in this year compared to last year.

Table 19: Nut and female flower production of the treatment palms

Treatment	Nut yield (palm/yr) (Oct. 2005 to Sept. 2006)	Female Flowers (palm/yr) (Oct. 2005 to Sept. 2006)
T1	64	248
T2	58	269
T3	60	248
T4	70	270
Level of Significance	ns	ns
LSD (p ≤ 0.05)	-	-

Leaf samples were collected in April 2006 and the leaf nutrient levels of 14th leaf are given Table 20. The nutrients have not shown significant difference among the treatments in

this year. The major nutrients such as N, P & K were in the sufficiency range and magnesium was little below the critical level in some palms.

Table 20: Leaf nutrient levels of the experiment

Treatment	N %	P %	K %	Mg %
T1	1.97	0.14	1.33	0.24
T2	1.89	0.14	1.49	0.25
T3	1.98	0.14	1.38	0.23
T4	1.99	0.14	1.38	0.25
Level of Significance	ns	ns	ns	ns

Soil sampling was done in June 2006 and the soil nutrient values are given in Table 21. The K nutrient of the top soil (0-20 cm) and N & P of sub soil have shown significant differences among the treatments and pH & EC of top soil (0 - 20 cm) and pH of sub soil (20 - 40 cm) have shown significant differences among the treatments.

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Table 21: Soil nutrient levels of the experiment

Treatment	pH (1:5)		EC(μ s/cm)		N (mg/kg)		P (mg/kg)		K(meq/100g)		Mg(meq/100g)		Ca(meq/100g)		Na(meq/100g)	
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
T1	6.29	6.19	107.48	87.57	71.98	106.27	165.50	22.90	0.77	1.02	1.45	1.69	2.56	4.33	0.12	0.09
T2	6.39	6.27	93.10	90.57	75.73	81.68	76.00	58.12	0.63	1.19	1.75	1.59	2.69	3.46	0.10	0.11
T3	6.65	6.51	84.82	82.27	61.18	54.97	174.32	52.47	1.40	0.62	1.72	1.60	2.99	3.34	0.11	0.10
T4 (MOP)	6.78	6.57	104.50	27.32	75.47	86.13	170.72	111.97	0.83	0.93	1.58	0.74	2.35	2.09	0.11	0.07
T4 (Kieserite)	6.50	6.43	69.00	60.23	73.55	88.34	151.20	38.08	0.31	0.44	1.64	1.18	1.29	4.12	0.08	0.12
Level of Significance	***	**	*	ns	ns	**	ns	***	ns	ns	ns	ns	ns	ns	ns	ns
LSD	0.162	0.200	19.49	-	-	23.177	-	12.312	-	-	-	-	-	-	-	-

(I) Soil depth at 0 - 20 cm

(II) Soil depth at 20 - 40 cm

PROJECT 10: DEVELOPMENT OF DRIP IRRIGATION SYSTEM FOR LAND SUITABILITY CLASSES 3, 4 AND 5

Experiment 10.0.1: Designing a suitable drip irrigation system for coconut in Andigama series soil (1996)

The experiment design was a Randomized Block Design with 3 replicates and 6 palms (15 years old) per plot and was established in 1996 at Ratmalagara Estate (IL1). It was located on a shallow sandy clay loam soil (Andigama series) categorized into land suitability class S5. A sub-terrain reticulated system and screw drippers were installed to provide different quantities of water to coconut palms at different irrigation intervals.

The treatments were given in Table 22.

Table 22: Treatments effect from November 2002

Treatment	Irrigation intervals in days	Application of water per day/palm in liters	Application of water per day/palm in hours	Rate of application of fertilizer	No. of time of fertilizer application per year
T1	-	-	-	3 kg	1
T2	6	40	2	3 kg	1
T3	3	80	2	3 kg	1
T4	6	40	2	250 g	12
T5	3	80	2	250 g	12

The objectives were achieved in this experiment within a ten-year period. Among them

- (i) Optimum flow rate of the drippers was 30 l/hr for 2.5 hours in Andigama series soil and it gave the maximum wetted volume of soil in the effective root zone.
- (ii) Optimum irrigation interval was 8 days with the evapotranspiration of 2.52 ± 1.12 mm/day.
- (iii) For a drip irrigation system, the number of drippers required was 4 and should be placed in a square with equidistance.
- (iv) Moisture extraction was highest at 100 cm away from the base of coconut palm.
- (v) The best distance for the placement of drippers was 100 cm away from the base of the palm.
- (vi) Roots distributed between 50 - 100 cm had significantly higher ($p \leq 0.01$) level of water absorption.
- (vii) Soil moisture absorption regime study showed that the moisture stored at 20 - 120 cm depth range from the surface was highly extractable to coconut roots.
- (viii) Physical properties of the Andigama series soil showed that the clay fraction and the percentage of gravel were significantly higher in the B horizon compared to the other horizons. The bulk density of the B horizon was also higher (1.65 ± 0.07 g/cm³) and the infiltration rate was $< 4 \pm 0.5$ cm/hr.
- (ix) Root distribution study showed that 75 - 80% of coconut roots was concentrated at the depth of 20 - 100 cm range. Only 5% of the total roots grow beyond 100 cm away from the base. About 15 - 20% of roots were localized in the top layer which lies 0 - 20 cm depth.

- (x) Nut yield did not show significant difference among the irrigation treatments but it was clearly evident that 30 - 45% yield increase between irrigated and non - irrigated coconut palms.
- (xi) Application of water at the rate of 40 l/palm/day with an interval of six days and split application of fertilizer for 12 months gave 30 - 45% yield increase in Andigama soil series

Therefore it was decided to terminate this experiment at the Research Committee Meeting held in July, 2006.

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Experiment 10.0.2: Evaluating the effect of fertigation on coconut

The experiment was established in 2004 at Ratmalagara Estate (IL1). It was located on a shallow sandy clay loam soil (Andigama series) categorized into land suitability class S5. This experiment was Randomized Complete Block Design with 3 replicates and 6 palms (15 years also) per plot. Treatment combinations were given in Table 23.

Table 23: *Treatment combinations of the experiment*

T1	Control – no Fertilizer, No Irrigation (No Fertigation)
T2	Fertilizer (3 kg APM + 1 kg Dolomite applied on the entire manure circle) + No Irrigation
T3	No Fertilizer + Drip Irrigation (40 l/day)
T4	Fertilizer (3 kg APM + 1 Dolomite – applied on the entire manure circle) + Drip Irrigation (40 l/day)
T5	Fertilizer (67 g urea + 133 g MOP through drippers/palm/month) + (Fertilizer 75g ERP + 83 g Dolomite applied at the point of 4 drippers) + Drip Irrigation (40 l/day)
T6	Fertilizer (67 g urea + 133 g MOP + 75 g ERP + 83 g Dolomite/palm/month with Hose Irrigation (40 l/day)

Nut yield records for two year period are given in Table 24. Treatments were imposed in October 2006 and leaf samples were collected in July 2006. Nut yield has not shown significant difference among the treatments in this year too.

Table 24: *Nut yield data of the experiment*

Treatment	Nut yield (palm/y)	
	November 2004 to October 2005	November 2005 to October 2006
T1	52	94
T2	41	80
T3	48	89
T4	46	89
T5	57	103
T6	55	99
Level of Significance	ns	ns

The leaf nutrient levels are given in Table 25 showed that there was no significant difference among the treatments. All nutrient levels were in the sufficiency range except Mg. ($N \geq 1.9\%$, $P \geq 0.11\%$, $K \geq 1.2\%$, $Mg \geq 0.25\%$, $Ca \geq 0.35\%$, $Fe \geq 40\text{ mg/kg}$).

Table 25: Leaf nutrient values of the 14th leaf

Treatment	N %	P %	K %	Mg %	Ca %	Fe (mg/kg)
T1	1.99	0.12	1.76	0.19	0.40	88
T2	1.98	0.13	1.65	0.22	0.46	94
T3	1.92	0.12	1.71	0.22	0.46	91
T4	2.01	0.13	1.62	0.22	0.46	104
T5	1.93	0.12	1.70	0.23	0.45	95
T6	2.01	0.14	1.77	0.24	0.45	95
Level of Significance	ns	ns	ns	ns	ns	ns

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Experiment 10.0.3: Rain water Harvesting and girdle sprinkler system for fertigation of coconut through rain water harvesting (CESS Funded)

The experiment was established in 2006 at Pallama Genetic Resource Center.

The objectives of the experiment were to

- Assess the yield increase through sub surface irrigation
- Study the use of harvested rain water for fertigation
- Study the salinity development in soil

Excavation of rain water harvesting pond was completed. In order to prevent the water losses through seepage, the lateral walls of the pond have been plastered with concrete mixture. The items for the installation of the sub surface irrigation system were received and lay out to be done in next year.

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PROJECT 27: STUDIES ON CHEMICAL AND MINERALOGICAL PROPERTIES OF COCONUT GROWING SOILS

Experiment 27.0.1: Evaluation of nutrient status of coconut growing soils (Nutrient Mapping - 1992)

The objective of this experiment was to determine available nutrients in all major soils in the coconut growing areas and to attempt to establish threshold levels for each nutrient in the coconut growing soils. Soil samples were collected to represent the top layer (0-25 cm depth) and the sub layer (25-50 cm) of soil series. Samples were obtained at the frequency of one sampling location per every 100 ha. Soil samples were taken from each location to represent the manure circle of the coconut palm as well as the centre of the square.

Leaf samples (14th frond) from coconut palms were also taken from the same location. The soil series Kuliypitiya, Kurunegala, Boralu and Pallama were sampled and analyzed for soil and leaf nutrient levels. The results were published in the past Annual Reports.

Soil and leaf sampling for another major soil series of Kurunegala 1 inch sheet namely Wariyapola (50,053 ha) and Maho (16,533 ha) were commenced from January 2005. It was planned to complete sampling of 250 sites from Wariyapola series and 50 sites from Maho series. At the end of the year, the soil and leaf samplings were completed in both soil types and analysis were in progress.

At each site soil samples were collected from 4 locations to prepare composite samples separately from top soil (0-25 cm) and sub soil (25-50 cm).

In leaf sampling, leaflets from 14th frond of four coconut palms were collected to prepare a composite sample from each site.

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PROJECT 30.1: STUDIES ON LONG TERM EFFECT OF ORGANIC MANURE APPLICATION TO COCONUT

Experiment 30.1.1: Comparison of the efficiency of three organic manures and a green manure (Gliricidia) against Adult Palm Mixture (APM)

The experiment, on a Randomized Block Design with 3 replicates and 6 palms (45 years old) per plot, was established in 1997 at Ratmalagara Estate.

The annual treatment application was as follows.

T1	-	Control (no fertilizer)
T2	-	3 kg APM (Adult Palm Mixture) + 1 kg dolomite per palm
T3	-	35 kg cattle manure + 1200 g MOP per palm
T4	-	25 kg goat dung + 800 g MOP per palm
T5	-	30 kg poultry manure + 250 kg MOP per palm
T6	-	30 kg Gliricidia + 750 g SP + 1500 g MOP + 1000 g dolomite per palm

Leaf samples collected at Ratmalagara Estate site on May 2006 were analyzed and results are given in Table 26. Leaf K & Mg levels have shown significant difference ($p \leq 0.01$ and $p \leq 0.05$) among the treatments. This difference was clearly shown between fertilized and non fertilized palms. Essential nutrients such as N, P, K and Mg were in the above critical level except K in no fertilizer applied palms ($N > 1.9\%$, $P > 0.11\%$, $K > 1.2\%$, $Mg > 0.25\%$).

Table 26: Leaf nutrient levels in 14th frond

Treatment	N %	P %	K %	Mg %
T1	2.30	0.14	0.93	0.28
T2	2.26	0.13	1.27	0.28
T3	2.20	0.14	1.46	0.30
T4	2.32	0.14	1.31	0.29
T5	2.30	0.15	1.21	0.35
T6	2.31	0.13	1.44	0.33
Level of significant	ns	ns	**	*
LSD ($p \leq 0.05$)	-	-	0.202	0.045

Nut yield of the palms receiving poultry manure was significantly increased ($p \leq 0.05$) by 52% compared to that of the control (no fertilizer) while the yield increases by inorganic fertilizer over the control (no fertilizer) was 24% (Table 27). Among other organic sources such as cattle manure, goat manure and gliricidia, the yield increase was 43%, 33% and 22% over the control (no fertilizer) respectively. Twenty three percent yield increases was observed in palms receiving poultry manure over inorganic fertilizer (APM-W). Results indicated that the application of organic manure such as poultry manure, cattle manure, goat manure etc were more economical and beneficial than that of inorganic fertilizer.

Table 27: Nut yield data in the Ratmalagara Experimental Site

Treatment	June 1997 to August 2005 Nuts/palm	June 2005 to August 2006 Nuts/palm/yr
T1	437	67
T2	526	83
T3	574	96
T4	561	89
T5	615	102
T6	523	82
Level of Significance	* only in year 2002/2003	*
LSD ($p \leq 0.05$)	20.000	18.952

Table 28 shows the soil nutrient data of the experiment. Analyzed all parameters have shown significant differences among the treatments. Organic matter content of the soil has increased by 122% when applied organic manure than application of inorganic fertilizers. The CEC is also increased by 128% and 91% when application of gliricidia and poultry manure respectively over the application of inorganic fertilizer after nine years of continuous application of organic manure.

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Table 28: *Soil nutrient data of the experiment*

Treatment	pH (1:5)	EC ($\mu\text{s}/\text{cm}$)	N	P	K	Mg	Na	Ca	CEC m $\text{eq}/100\text{g}$	OC %
			< ----- mg/kg ----- >		< ----- meq/100 g ----- >					
T1	5.89	36.50	55.50	180.78	0.14	0.95	0.05	2.10	5.21	0.79
T2	6.45	32.37	71.25	281.05	0.18	0.87	0.04	2.64	4.85	0.74
T3	6.62	43.33	75.75	183.78	0.24	1.57	0.04	4.16	6.30	1.34
T4	6.76	56.90	49.25	192.35	0.23	1.49	0.05	6.59	9.28	1.65
T5	6.87	79.73	65.25	819.10	0.21	1.82	0.07	10.11	6.68	1.44
T6	7.07	41.23	48.25	538.31	0.25	1.61	0.06	5.90	11.08	1.18
Level of Significance	***	***	*	***	**	**	*	***	*	**
LSD ($p \leq 0.050$)	0.160	16.709	18.399	87.65	0.045	0.464	0.016	1.909	4.181	0.380

Experiment 30.1.2: Amelioration of Boralu and Sudu series soil by adding organic manure for improvement of the soil

The objective of the experiment was to study the rate of increase in soil organic matter with application of different levels.

The experiment on a Randomized Block Design with 3 replicates and 6 palms per plot was established in 2005 at Boralu soil series (potential nut yield is 5,000 - 10,000 nuts/ha/yr) at Badalgama in WL3 Agro Ecological Region. The site falls into land suitability class S4.

Treatments are given in Table 29.

Table 29: Treatments of the Badalgama site

T1	Control - only APM-W
T2	Goat manure 35 kg per palm/yr
T3	Goat manure 50 kg per palm/yr
T4	Goat manure 75 kg per palm/yr
T5	Goat manure 100 kg per palm/yr

Basal dosage (g/palm/y)	-	Eppawela Rock Phosphate	900
		Muriate of Potash	1600
		Dolomite	1000

Preliminary nut yields were completed for one year period and soil and leaf samples were also collected before application of the treatments. The site for Sudu soil series has been selected at Madampe in this year. The site is in IL3 Agro Ecological Region. The site falls into land suitability class S4 (5,000 - 10,000 nuts/ha/yr).

The treatments of the site at Madampe are given in Table 30.

Table 30: Treatments of the Madampe site

T1	Control - only APM-W
T2	Cattle manure 50 kg per palm/yr
T3	Cattle manure 75 kg per palm/yr
T4	Cattle manure 100 kg per palm/yr
T5	Gliricidia 50 kg per palm/yr
T6	Gliricidia 75 kg per palm/yr
T7	Gliricidia 100 kg per palm/yr

Basal dosage (g/palm/y)	-	Eppawela Rock Phosphate	900
		Muriate of Potash	1600
		Dolomite	1000

Plots demarcating was completed and preliminary nut yields recording is in progress.

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Experiment 30.1.3: Assessment and improvement of soil quality depletion in coconut lands (CESS Funded)

The objectives of the experiment were

To assess the depletion of soil quality in coconut lands after introduction of coconut
To improve the soil quality in coconut lands

The experiment has established in 3 locations i.e. Rathmalagara, Pallama and Walpita.

The Agro Ecological Regions, land suitability classes and soil types of these locations are given in Table 31.

Table 31: *Agro Ecological Regions, land suitability class and the soil types of the experimental sites*

Location	AER	Land Suitability Class	Soil Series
Rathmalagara	IL1	S2 & S4	Wilattawa (S2) and Andigama (S4)
Pallama	IL3	S2 & S4	Wilattawa (S2) and Andigama (S4)
Walpita	WL3	S2 & S4	Pallama (S2) and Boralu (S4)

Soil samples were collected from center of the squares of a coconut land and adjoining forest land which consist of S2 and S4 land suitability classes. Such six sampling points were selected in each land suitability class in coconut lands as well as forest lands at two depths (0-20 cm and 20-40 cm). All together 144 soil samples were collected from coconut lands and forest lands in 3 locations.

Soil samples were analyzed for chemical, physical and biological parameters. The available data at Ratmalagara and Pallama sites are given in Tables 32 and 33. The chemical and physical analysis of soil at Walpita sites were in progress.

The results envisages that in Ratmalagara site, continuous cultivation of coconut for a long time even with the recommended management practices caused substantial reduction of N, P and K contents in both land suitability class soils (i.e. S2 – suitable to highly suitable and S4 – marginally suitable) when compared with those in undisturbed, forest soils. The percentage depletions of all three nutrients were close to 20% in S2 while the same was more than 40% in marginally suitable S4 soils. The reduction of soil N content was more prominent in marginal suitable soils with more than 80% drop compared to those of undisturbed soils. The nutrients Ca and Mg contents were > 90% lower in cultivated soils compared to those in virgin soils. The trend was similar in both considered soil types. A reduction of some micro nutrients up to a level of 15% (especially Zn, Mn and Cu) was observed in cultivated S2 soils compared with forest soils. In S4 coconut soils 5% reduction was on served for Zn and Cu while it was more than 75% for Mn due to coconut cultivation. More than 70% higher Fe content was reduced in cultivated, marginal soils (S4) compared with forest soils (S4).

This reduction in both major and micro nutrients in cultivated soils may primarily be due to the high removal of those nutrients by coconut palms without comparable replenishment of nutrients by fertilizer applications. The drop of organic carbon content by

about 50% in both highly suitable and marginally suitable soils indicate a substantial reduction in application of organic manure to those soils which ultimately leads to a reduction in nutrient and moisture holding capacity thus contributing to a greater nutrient leaching.

Moreover, coconut cultivation caused a reduction of soil pH i.e. 5.06 and 4.99 in S2 and S4 respectively compared with virgin S2 and S4 soils i.e. 5.80 and 5.95 respectively.

In addition, bulk density of the top layer of the soil (25 cm depth) was increased by about 12% and 40% respectively in suitable and marginally suitable coconut soils causing a negative impact for root growth. Soil moisture content at field capacity was more than 70% higher in undisturbed forest soil compared to that of cultivated good soils (S2). Forest soils even with marginal suitability (S4) showed about 60% greater water holding at field capacity compared to a similar soil under long term coconut cultivation. Monitoring of soil moisture contents under drought condition is still in progress for the construction of a soil moisture depletion patterns in both soil categories under forest and cultivated conditions.

Table 32: Chemical and physical parameters at RE site

Parameters	Land Suitability Class S2		Land Suitability Class S4	
	Forest land	Coconut land	Forest land	Coconut land
pH	5.80	5.06	5.95	4.99
EC	21.59	18.53	55.12	26.75
N	23.70	21.34	210.12	42.50
P	9.24	6.98	10.12	6.67
K	0.09	0.07	0.18	0.11
Na	0.03	0.03	0.05	0.02
Ca	1.45	0.13	3.18	0.14
Mg	0.81	0.10	1.95	0.73
Zn	5.00	4.45	5.31	5.08
Cu	1.12	0.89	1.19	1.12
Fe	31.02	25.40	16.12	27.71
Mn	17.12	14.74	100.80	25.72
Cl	16.34	15.63	17.46	13.29
OC	0.74	0.40	1.46	0.49
BD	284.48	314.95	225.17	314.32

The impact of long term coconut cultivation on soil aspects of Pallama site was more or less similar that of Rathmalagara site with only some quantitative differences. Although the N and K contents were only slightly lower in cultivated, highly suitable land category (S2), P content was more than 60% lesser compared to that of virgin soils. More than 30% reductions was observed in the above three nutrients in marginal soils. The loss of Ca and Mg was about 40% in marginal soils (S2) while it was substantially higher in suitable soils (S2) with losses more than 80% and 50% respectively. This indicates a greater removal of nutrients by coconut palms grown in good soils. The reduction of Zn was more prominent (12%) in good soils (S2) while the Mn showed greater reductions (20%) in marginal soils (S4). However, this drop of Mn to a level of 76.1 mg/kg was much lesser to that of Rathmalagara Research Station where it dropped to a level of 25.7 mg/kg. Fe levels were higher by 70% in cultivated soils in both soil categories while Cl levels were 70% higher only in suitable soils but with slight increase in marginal soils.

The drop of organic carbon content was more or less similar in both soil categories and comparable with those in RE site. The reduction of pH and the increase of bulk density were similar to those at RE and the impacts were the same as described above.

Soil moisture content at field capacity was about 40% higher in undisturbed forest soil compared to that of cultivated good soils (S2). Marginal soils in undisturbed forest showed about 60% greater water holding at field capacity compared to cultivated same. Monitoring of soil moisture contents under drought condition is still in progress for the construction of a soil moisture depletion curves in both soil categories under forest and cultivated conditions.

Table 33: Chemical and physical parameters at Pallama site

Parameters	Land Suitability Class S2		Land Suitability Class S4	
	Forest land	Coconut land	Forest land	Coconut land
pH	6.38	5.54	6.62	6.15
EC	33.47	20.63	49.63	28.44
N	12.74	12.29	133.69	99.81
P	13.00	5.44	8.40	6.00
K	0.04	0.02	0.03	0.01
Na	0.13	0.08	0.58	0.40
Ca	5.61	1.06	7.82	4.58
Mg	1.23	0.60	1.90	1.36
Zn	2.05	1.81	2.17	1.89
Cu	0.57	0.54	2.06	1.75
Fe	17.73	29.31	21.89	22.49
Mn	33.65	26.28	88.87	71.67
Cl	9.16	16.29	6.63	11.64
OC	0.72	0.34	1.50	0.85
BD	305.26	347.48	265.98	336.15

3. SERVICE FUNCTIONS

Differential Fertilizer Recommendation	-	120 growers (1300 ha)
Land suitability tests for coconut cultivation/surveys	-	40 growers
Inorganic fertilizer analysis	-	310 samples
Organic fertilizer analysis	-	110 samples
Analysis of coir pith samples	-	725 samples
Soil analysis	-	1570 samples
Leaf analysis	-	1509 samples
Water analysis	-	15 samples
Participation in training programmers	-	06

4. ACKNOWLEDGEMENT

Sincerely thank the staff members of the Division for their support in carrying out the experiments smoothly and the Head and the staff of the Biometry Division for the assistance in designing field experiments and statistical analysis of data.

REPORT OF THE CROP PROTECTION DIVISION

Head – L.C.P. Fernando, Phd

1. GENERAL

The research on coconut mite was focused on several directions involving studies on biology and ecology of the pest and its natural enemies, identifying tolerant coconut cultivars and developing management strategies using biological and chemical methods.

In contrast to the rapid increase in the coconut mite population in 2005, a decline was recorded in 2006. Compared to the previous year the predatory mite *Neoseiulus baraki* population was also low. The data of 2000 – 2006 revealed that in general both populations were higher during June-August period, which were generally drier months and lower during November. A survey to determine the composition of the predatory mites, *N. baraki* and *N. paspalivorus* present in infested areas of different agro-ecological regions confirmed that *N. baraki* was mainly confined to dry areas while both species were found in intermediate and wet areas. Both *N. baraki* and *N. paspalivorus* were associated with nuts infested by the nut infesting mites, *Dolichotetranychus* nr sp. *cocos* and *Colomerus novaehbridensis* in areas free of coconut mite indicating their presence in the country before the invasion of coconut mite.

The movement patterns of the predatory mite *N. baraki* in the field were studied. *N. baraki* moved out from the perianth of nuts when the average temperature of the canopy increased during the day. They moved within the palm by walking and movement between palms was aided by air currents. Most *N. baraki* left their habitat during the day than at night, and moved more into other infested nuts at night compared to the day. Majority of *N. baraki* that moved were females. It appeared that movement of *N. baraki* affects population levels of coconut mite.

The CARP funded project to develop chemical and biological methods to manage coconut mite was completed. Two technologies, “dry culture” and “sachet” methods were developed for mass rearing of *N. baraki*. A nearly 110-fold increase in *N. baraki* was obtained by dry culture method and sachet method in 3 and 6 weeks respectively. The new arenas need less maintenance and are mostly contaminant-free. Development of technologies for field releases of *N. baraki* was continued. The release rates of 2500, 5000 and 10,000 mites/palm did not show a significant impact on reducing the pest density, but the proportion of healthy nuts and the nuts with discontinuous patches were higher in the palms that received 5000 predatory mites/palm. Release of *N. baraki* in 2-, 4- and 6-monthly intervals at a rate of 5000 mites/ palm did not considerably reduce the pest density. However, 4 months after the first release, the fraction of nuts without damage highest on the palms that received predatory mites at 2-monthly intervals.

The collaborative project with CABI Bioscience, U.K. funded by the Department for International Development, U.K. to develop a management method for coconut mite using the entomopathogenic fungus *Hirsutella thompsonii* was completed and the studies were continued under the CFC/DFID/FAO/APCC project. A study initiated to determine the suitable frequency of application of the isolate IMI 391722 indicated that percentages of damaged, normal-sized nuts and damaged smaller-sized nuts at harvest were less in the plots treated at 2- and 3-monthly

intervals compared to the untreated plot. Due to the constraints in using the fungus cultured on solid (rice) medium, the effectiveness of alternative culture mediums were evaluated with the view of selecting one for mass production and formulation. Studies indicated that the liquid medium was nearly effective as the rice medium in reducing the coconut mite population. A collaborative project with Industrial Technology Institute was commenced to develop and test prospective mycoacaricide formulations.

Pilot trials were commenced to confirm the effectiveness of 20% palm oil and 0.05% wettable sulphur in managing coconut mite. Data indicated that 3 months after application, the damage has been discontinued on a high proportion of infested nuts and the percentage of fresh damage have been reduced significantly on treated bunches. Further, the damage on newly developing bunches have greatly reduced due to the treatment than that present at the time of treatment. Field-testing of soil application of neem based granules (Azadirachtin 1500ppm), spraying of NeemAzal 1% (Azadirachtin 1%) and root feeding of Neem Raj supreme (Azadirachtin 10,000 ppm) were commenced.

The tolerance of three improved coconut cultivars; Dwarf Yellow X Tall (DYT), Dwarf green X Tall (DGT) and Tall X Tall (TT) against coconut mite was studied with respect to the total mite population and damage. The nut shape as measured by ratio of length: breadth and tightness of perianth that would lead to the tolerance were investigated. Significantly low population levels of coconut mites, lowest level of damage on the 4-month old bunch and a minimum crop loss of 5% were recorded in DYT. This variety had the lowest length to width ratio, which leads to a more round shape and the lowest distance between the perianth and the nut surface. Hence, DYT could be considered as a tolerant cultivar to coconut mite.

The survey was conducted in 97 holdings of 279 ac. in four CDO ranges Ahangama, Dickwella, Matara and Weligama on the incidence of leaf rot disease. Highest percentage of diseased palms (30.6%) was reported from Weligama area. Leaf analysis of affected palms showed lower levels of sodium and higher levels of iron, manganese, copper levels irrespective of the estate, soil type and disease condition. A study was initiated to determine the effect of application of organic manure on the disease.

Preliminary studies showed that Dithiocarbamate fungicides at 3.2 g of active ingredient/l could be used for the control of leaf blight disease in coconut seedlings.

An improved electronic device was developed to detect red weevil infested palms under the collaborative research project with the Rinzen Laboratories (Pvt) Ltd. funded by the CARP. Field-testing indicated that the device was efficient and reliable in detecting infested palms but it required further improvements.

Under the CFC/DFID/FAO/APCC project on integrated pest management of *Oryctes* beetle four treatments viz. *Oryctes* pheromone, Green muscardine fungus (GMF), *Oryctes* virus (*OrV*), *OrV*+GMF and integrated were evaluated for the management of black beetle. The damage in plots installed with pheromone traps reduced over time while results of other treatments were not consistent. The *OrV* incidence in beetles trapped in pheromone traps increased over time. A survey conducted in Kurunegala District showed that the natural

incidence of *ORV* was about 30%. Two technologies for on-farm production of GMF using maize grains and black beetle larvae were developed.

The Division continued to serve the coconut growers during the year. Advice on management of pests and diseases were given while field inspections were made in instances where specialized advice was required. Two epidemics of bud rot and leaf blight diseases were managed successfully.

2. RESEARCH PROJECTS

PROJECT 27 CONTROL OF COCONUT MITE, *ACERIA GUERRERONIS* (1999)

Experiment 27.11 Studies on population fluctuations of coconut mite, *Aceria guerreronis* and the predatory mite, *Neoseiulus baraki* (1999)

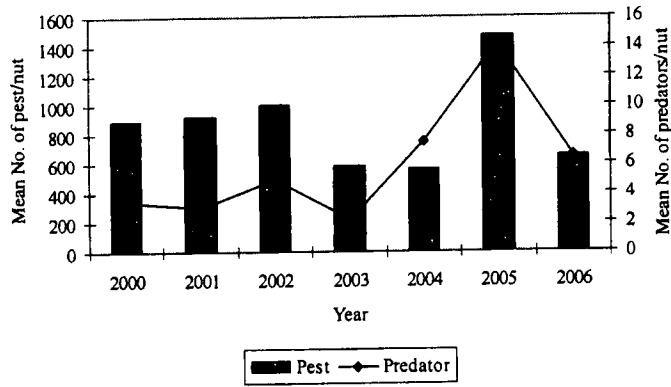
The experiment conducted to determine the annual and seasonal population fluctuation pattern of coconut mite and *N. baraki* in Kalpitiya, Madurankuliya, Rajanganaya and Yakwila was continued in 2006. One young nut (4 - 6 months old) from each 5 - 10 palms in each site (3 sites per area) was sampled during February, June, August and November which are correspondent to the dry, wet but with less intense rainfall, dry and wet with intense rainfall periods respectively. Nuts were brought to the laboratory and the total number of live individuals and eggs of *N. baraki* was counted under a stereo microscope. The number of coconut mite was estimated using the "wash method".

Log transformed data for the period of 2000 to 2006 in Kalpitiya and Madurankuliya were analyzed by Generalized Linear Model using SAS. Data for Rajanganaya and Madampe were not statistically analyzed due to insufficient data in 2003 and 2004. Populations of both pest and predator fluctuated over time in all sites (Fig. 1). There was a significant effect of year, season and the year x season interaction on both pest and predator populations. However, although not statistically correlated, in general both populations were higher during June-August period and lower during November. Pest and predator populations did not show a direct correlation to each other. Rainfall (both amount and intensity) and relative humidity did not appear to show any effect on the pest or predator populations. However, in Kalpitiya, duration of the dry season appears to have an effect on the pest population (Pearson correlation coefficient 0.43, $p=0.02$, $N=26$) as well as the predator population (Pearson correlation coefficient 0.39, $p=0.04$, $N=26$).

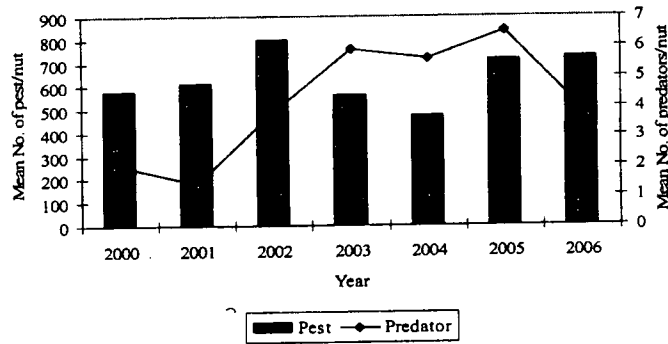
The experiment was terminated and a new experiment will be initiated in 2007 including 2 new areas, viz Gampaha and Kurunegala.

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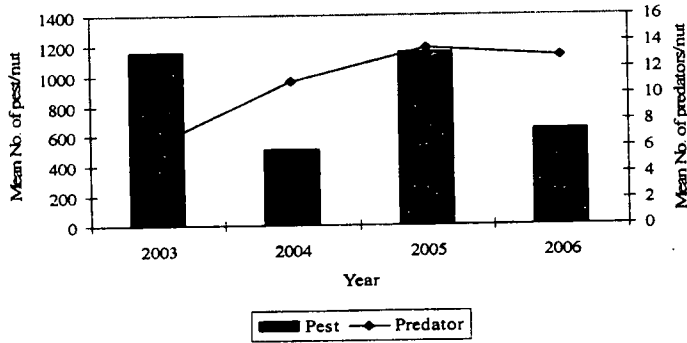
A



B



C



D

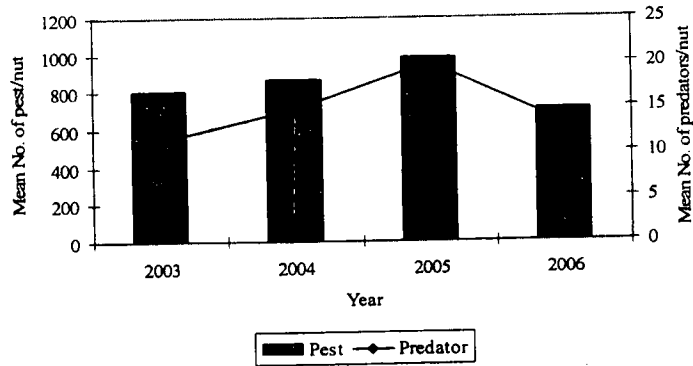


Figure.1. Annual population fluctuation of coconut mite and *N. baraki* in (A) Kalpitiya, (B) Madurankuliya, (C) Rajanganaya and (D) Madampe

Experiment 27.52 Mass rearing of *N. baraki* in the laboratory (2004)

The major constraint in mass rearing of *N. baraki* in the laboratory is frequent contamination of *N. baraki* and *T. putrescentiae* cultures by other mites. Invasion of a *Laseoseius* sp. (Ascidae) prevented continuous rearing of *N. baraki* on several occasions. Therefore, it had been necessary to improve the efficiency of the rearing method by developing an arena that needs less maintenance and prevent contaminations. Two improved rearing methods viz. "dry culture" and "sachet" methods were developed.

a. "Dry culture" method

The arena consisted of a black plastic sheet of 30cm x 38cm pasted on a plastic tray (35cm x 44cm). Insect glue was applied along the periphery of the sheet to prevent escape of the predators and to safeguard the arena from contaminants. A wet plastic foam pad (10cm x 10cm) wrapped with a tissue paper provided the mites with drinking water. Plastic foam pad was placed on a glass sheet of the same size on a piece of net, which served as an egg laying substrate for predatory mites. The sponge was wetted 2-3 times a week depending on the requirement (c. 10 ml/time). Approximately quarter teaspoon of rice bran was spread on the plastic sheet as the food source of *T. putrescentiae*. The same arena was used to rear both *N. baraki* and *T. putrescentiae*. *T. putrescentiae* was introduced to the arena by dusting (c. 2000 mites/tray) from their mother cultures maintained separately. The trays were maintained under dark conditions by covering with an inverted plastic tray of similar size and at 26 ± 2 °C and around 75% relative humidity for 2 weeks before introducing the predatory mites. Approximately 50 females and 10 males of *N. baraki* were introduced to each tray and were maintained under same conditions.

From the cultures each of five culture trays were randomly drawn just before introduction of *N. baraki* and 3 weeks after introducing the predatory mites and the total numbers of *T. putrescentiae* and *N. baraki* were counted respectively. Approximately 130-fold increase in *T. putrescentiae* in 2 weeks and 110-fold increase in *N. baraki* in 3 weeks were achieved by this method. Three weeks after introducing the predatory mites and a total period of 5 weeks after introducing *T. putrescentiae*, cultures are ready for field releases.

The advantages of this method over the method developed earlier in 2004 are that the cultures can be maintained with relatively lesser intervention and relatively free of contaminants.

b. "Sachet" method

The arena consisted of a polypropylene sachet of 17cm x 10cm. In a partially separated chamber in one side of the sachet a moist tissue paper folded to a size of 4cm x 2cm was placed to provide drinking water to the mites and create a high relative humidity. A piece of styrofoam (app. 2 x 2 x 2 cm) was kept inside the sachet to prevent its two sides sticking together. Approximately 200 *T. putrescentiae* and 10 females and 3 - 4 males of *N. baraki* were introduced in to each sachet. One teaspoon of a mixture of rice bran (1 part) and wheat flour (1 part) was supplied as food source for *T. putrescentiae*. The open side of the sachet was sealed using a polyethylene sealer and placed in an incubator at 27 ± 0.5 °C. Another set of sachet was kept in an air-conditioned room (26 ± 2 °C). The food source was again added in 2 weeks. Ten

sachet were randomly chosen at 2-weekly intervals up to 6 weeks and the total number of *N. baraki* were counted. A mean number (\pm S.E.) of 917.20 ± 101.53 and 947.75 ± 92.45 *N. baraki* was recorded in cultures placed in the incubator and the air-conditioned room respectively at 4 weeks. At 6 weeks, approximately a 110-fold increase in *N. baraki* was recorded in the cultures placed in the incubator (Fig. 2). The advantages of this method are absence of contaminations, minimum maintenance and possibility of direct application of sachet in the field.

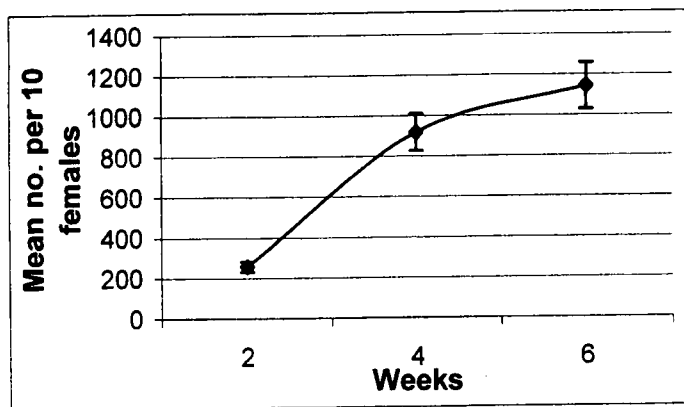


Figure.2. Mean (\pm S.E.) number of *N. baraki* per 10 females in sachet at different intervals after introduction

L. C. P. Fernando, A. D. N. T. Kumara, N. S. Aratchige, N. I. Suwndhrathne, K. F. G. Perera, P. H. A. R de Silva, N. Wijesinghe & C. Wijesinghe

Experiment 27.66 Determination of the movement pattern of *Neoseiulus baraki* from the infested nuts (2006)

A field study was conducted to determine the movement pattern of *N. baraki* from the nuts infested by coconut mite. Twenty coconut mite infested palms were selected and three infested nuts from the 4-month old bunch were marked in each palm. The surfaces of the nuts were observed and the predatory mites coming out from the perianth were collected in 70% ethanol for duration of one hour at 4 time periods (630 – 930h, 930 – 1230h, 1230 – 1530h and 1530 – 1830h) during the day. Canopy temperature and relative humidity were measured at the beginning and end of each time period.

The highest mean number \pm S.E. (7.4 ± 0.4) of *N. baraki* was recorded at 1230-1530h of the day and it was correspondent to the time period of the highest average temperature of the canopy (Fig. 3).

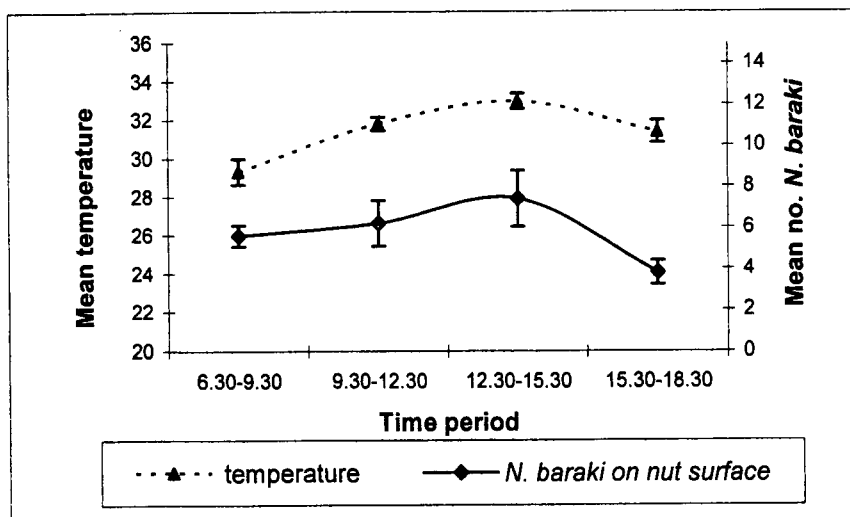


Figure. 3. Mean number of *N. baraki* and mean average temperature in the canopy at different time intervals

A. D. N. T. Kumara, L. C. P. Fernando & N. G. Premasiri

Experiment 27.67 Determination of the modes of movement of *N. baraki* from the palms infested by *A. guerreronis* (2006)

A field study was conducted to determine the modes of movement of *N. baraki* from the palms infested by coconut mite. Their movement by aerial means between palms and by walking within the palm were assessed using sticky traps and live traps respectively during day and night. Sticky traps made of transparent sheets coated with a thin layer of insect glue and were hung at the level of canopy of affected palms, at 1m distance from the canopy. Live traps were made from 4-month old, detached infested nuts. All stages of *N. baraki* were removed from the nuts and the bracts were rearranged using pins. The live traps were placed in the canopy region of the palms.

It was confirmed that *N. baraki* move within the palm by walking and between palms by the aid of air currents. The mean numbers trapped on sticky traps were significantly higher during the day (0.36) than at night (0.14). In contrast to the movement pattern out of the canopy, a significantly higher number of *N. baraki* moved with in the canopy at night (34.0) than during the day (17.0). A higher proportion (about 70%) of *N. baraki* that moved was females. The reasons for different movement patterns need to be investigated.

A.D. N. T. Kumara, L. C. P. Fernando, N. G. Premasiri,
N. I. Suwandhrathne & S. Mayadunne

Experiment 27.68 Determination of the effect of movement of *N. baraki* from the coconut mite infested nuts on the population levels of *A. guerreronis* (2006)

Laboratory and field studies were conducted to determine the effect of movement behavior of *N. baraki* on population level of coconut mite on a nut. Four-month old nuts infested by coconut mite were collected and randomly divided into 2 equal groups. Perianth of one group was sealed with masking tape to prevent *N. baraki* moving out of the bracts while the other group was left without sealing (control). The number of eggs, immature stages and adults of *N. baraki* and the total number of *A. guerreronis* on 5 nuts were assessed daily from day 2 to day 5. The field study was conducted in 3 sites. Twenty palms that had a minimum of 10 damaged nuts in the 4-month old bunch were selected at each site. On each bunch, 5 nuts were sealed (as per laboratory study) and another 5 were kept unsealed. One nut from each sealed and unsealed nuts was collected and the number of eggs, immature stages and adults of *N. baraki* and the total number of *A. guerreronis* were assessed at 3, 6, 9 and 12 days after initiation of the experiment.

A higher numbers of *N. baraki* were obtained under the perianth on nuts when their movement away from the perianth was prevented indicating that *N. baraki* frequently moves away from the infested nuts. This trend was observed both in laboratory and field tests (Fig. 4). Increasing density of *N. baraki* seemed to lower population levels of *A. guerreronis* on sealed nuts in the field (Fig. 5) as well as in the laboratory.

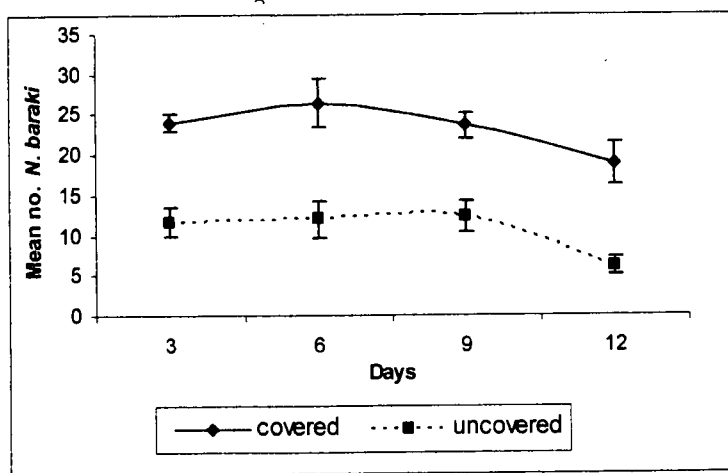


Figure 4. Mean number of *N. baraki* on covered and uncovered nuts at different time periods in the field

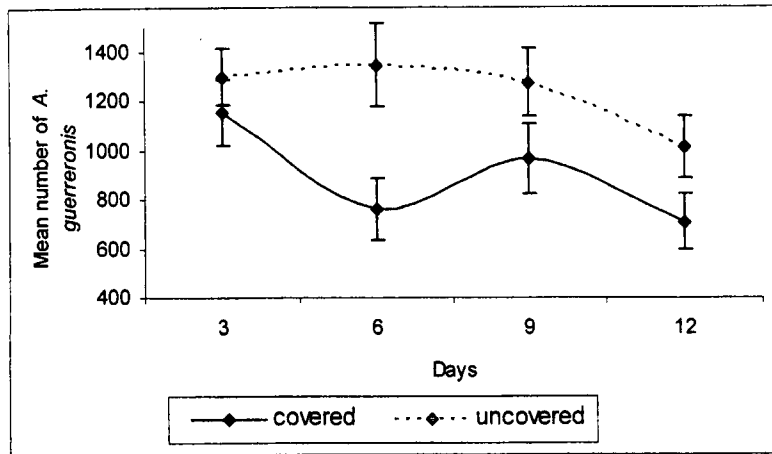


Figure. 5. Mean number of *A. guerreronis* on covered and uncovered nuts at different time intervals in the field

*A. D. N. T. Kumara, L. C. P. Fernando,
K. F. G. Perara & N. G. Premasiri*

Experiment 27.60 Effect of releasing laboratory bred *N. baraki* on coconut mite population (2005)

A study conducted in Margret estate and an estate at Battuluoya to determine the effect of releasing lab-bred *N. baraki* on the coconut mite population was completed. In each estate, 10,000 predatory mites were released on 5 infested palms in a block consisting of 60 coconut mite infested palms. Two nuts were collected from each released palm and 5 palms adjoining the released palms at 2-weekly intervals to assess the coconut mite and predatory mite populations. Also, 10 nuts were collected from an infested block far apart from the released block for comparison.

The results of covariate analysis showed that in both estates the pest populations in the released blocks were lower than the unreleased control blocks, up to 10 weeks at Margret estate and end of experiment at Battuluoya (Figs. 6 & 7). However, the coconut mite populations in the released block were significantly higher than the unreleased blocks only at weeks 4, 6, 24 and 2, 16, 20 at Margret estate and Battuluoya respectively. The predatory mite populations were higher than the control palms in both sites at all times. The results suggested that release of predatory mites has an impact on the coconut mite population.

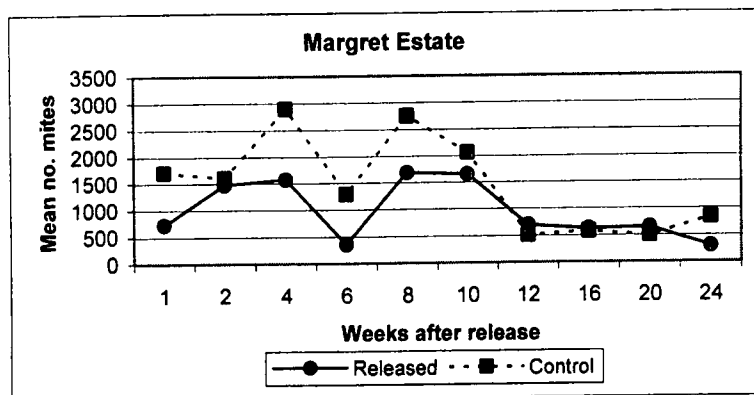


Figure. 6. Mean number of coconut mites on treated and control blocks after release of predators at Margret estate

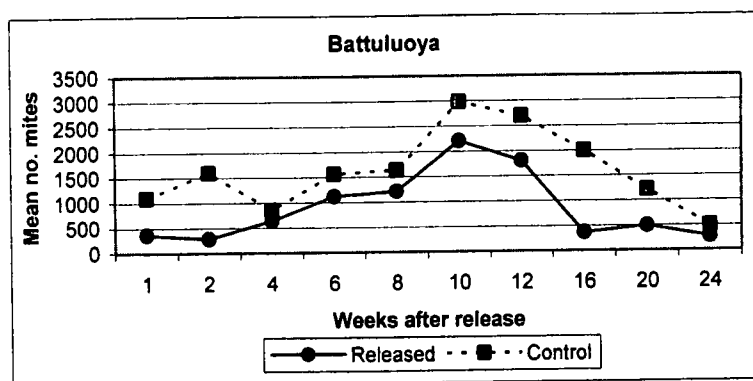


Figure. 7. Mean number of coconut mites on treated and control blocks after release of predators at Battuluoya

L. C. P Fernando, K.F. G. Perera,
P. H. P. R. de Silva & N. Wijesinghe

Experiment 27.69 Determination of a suitable dose of releasing *N. baraki* in the field (2006)

An experiment was conducted to determine the number of predatory mites required to be released on a coconut palm to reduce the pest population. The experiment was conducted in 3 sites, one in Battuluoya and two in Udappuwa. Laboratory reared *N. baraki* were released on to 3, 4 and 5-month old bunches of the infested palms. At each site 4 plots were selected, at least 5 coconut rows away from each other. Two centrally located palms at each plot received either, 2500, 5000 or 10,000 mites/ palm. Control plot was maintained without releasing *N. baraki*. Before releasing the predatory mites, two pre-release samples were collected (on two different days, one week apart from each other), 1 nut from the 4 or 5 month old bunch of each palm. Nuts were collected from two adjoining palms to each released palm. After releasing predatory mites, 1 - 2 nuts (depending on the availability of nuts) from 4 or 5 month old bunch of the released

palms, adjoining palms and the control palms were sampled at weekly intervals until 2 weeks after release and thereafter once a month up to 5 months. The total number of predatory mites and pest mites were counted at each occasion. Six months after the release, total number of nuts without any scars, infested nuts with continuous patches (patches continuing from the perianth) and the discontinuous patches in bunches on which the predatory mites were released were counted in each released, adjoining and control palms in Bangadeniya site.

Data on pest and predator counts were analyzed by Generalized Linear Model using SAS for Bangadeniya site and Udappuwa site 2 separately. Severe button nut fall occurred in Udappuwa site 1 during the experimental period. Hence, data were not analyzed for Udappuwa site 1 (due to insufficient data). In Bangadeniya site, there were no significant differences in pest counts among different doses (Fig. 8A). But the predator counts were significantly higher in the palms that received 5000 predatory mites per palm compared to the control as well as to the other doses tested ($p < 0.0001$). In Udappuwa site 2, the doses tested were not significantly affecting both the pest and predator populations (Fig. 8B).

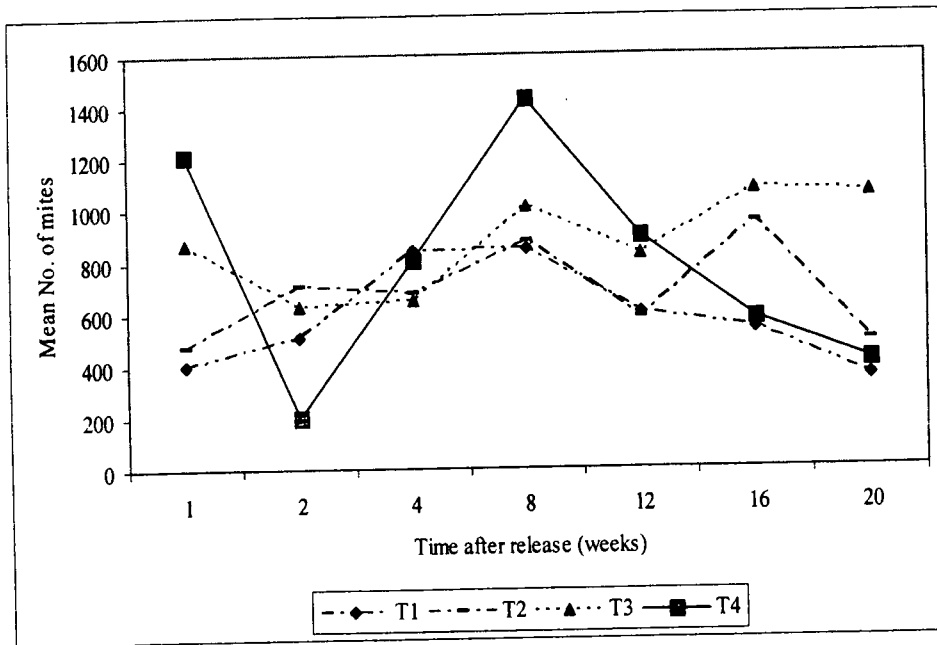
Data on harvest records of the released bunches showed that the percentage of nuts with no scars and the nuts with discontinuous patches were higher in the palms that received 5000 predatory mites/palm (Table 1). Based on this result, 5000 predatory mites per palm will be released in further studies.

In adjoining palms, effect of different doses was not indicated in terms of mite census or harvest records of the released bunch.

Table 1. *Percentage nuts with no scars and nuts with discontinuous patches at harvest in released bunches in the palms that received 2500 predatory mites/palm (T1), 5000 predatory mites/palm (T2), 10000 predatory mites/palm (T3) and control palms (T4) in Bangadeniya*

Treatment	Nuts with no scars	Nuts with discontinuous patches
T1	27	0
T2	44	17
T3	28	0
T4	28	8

A



B

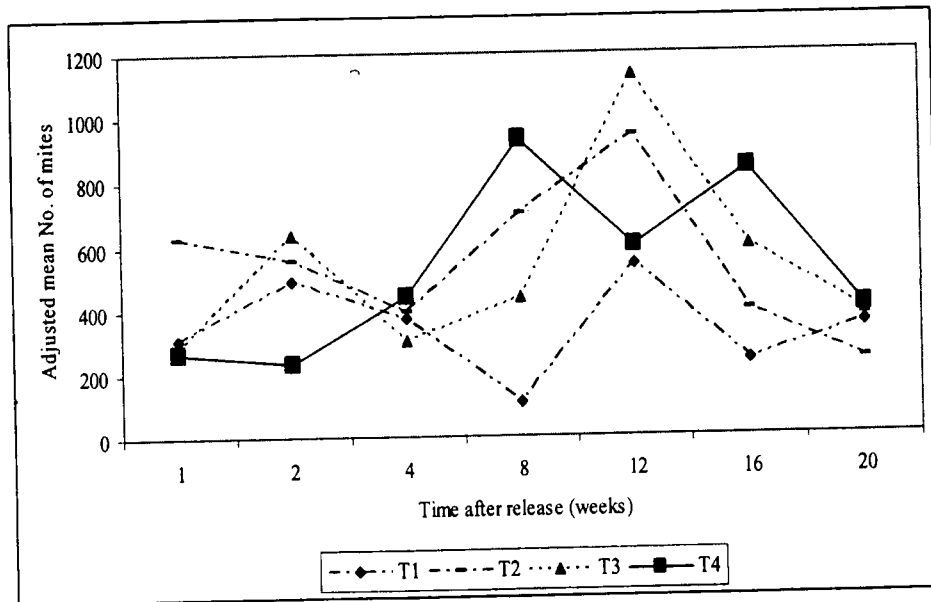


Figure 8. Fluctuation of coconut mites after releasing 2500 predatory mites/palm (T1), 5000 predatory mites/palm (T2), 10,000 predatory mites/palm (T3) and control (T4) in Bangadeniya (A) and Udappuwa site 2 (B)

N. S. Aratchige, K. F. G. Perera, P. H. P. R. de Silva, C. Wijesinghe, N. Wijesinghe & C. Hettiarachchi

A study was initiated in Weragoda Estate, Pallama to determine a suitable frequency for releasing *N. baraki* in the field to control the coconut mite. Four 1 ac. plots (at least 6 rows away from each other) were selected. Ten coconut mite infested-palms from each plot received 5000 predatory mites/palm and the releases were repeated either at 2-monthly or 4-monthly or 6 monthly intervals in each plot. Control plot was maintained without release of *N. baraki*. Before releasing the predatory mites, one pre-release sample was collected (one week before the first release), 1 nut from the 4 or 5-month old bunch of each palm. After releasing predatory mites, 1 nut from 4 or 5-month old bunch of the released palms, 5 adjoining palms and control palms were sampled at 2 weeks after release and thereafter once in 2 months. Total number of eggs and other stages of predatory mites and the total pest population were assessed. From 4 months after the 1st release matured nuts were harvested at 2 monthly intervals and total number of infested nuts, uninfested nuts, full-priced nuts, half-priced nuts and barren nuts were counted from each palm.

Compared to the pre counts a considerable reduction in the pest population was not observed in any treated plot. However, 4 months after the first release, the fraction of nuts without damage (on 3 or 4 or 5-month old bunch) was highest on the palms that received predatory mites at 2 monthly intervals (0.6) compared to the palms that received predatory mites at 4 monthly intervals (0.0), 6 monthly intervals (0.0) and the control (0.1) (Fig. 9). The study is in progress.

*N. S. Aratchige, L. C. P. Fernando, K. F. G. Perera,
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N. Wijesinghe & C. Hettiarachchi*

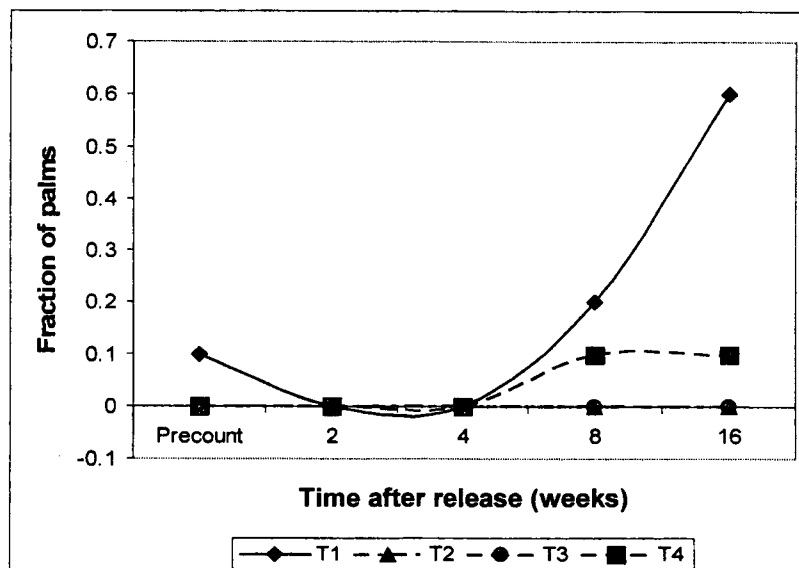


Figure. 9. Fraction of nuts without damage on 3, 4 and 5-month old bunches after release of *N. baraki* at 2- monthly (T1), 4-monthly (T2) and 6-monthly (T3) intervals and in the control (T4) at different times after the releases

Experiment 27.71 Effect of mass release of *N. baraki* in controlling coconut mite in the field (2006)

An experiment was initiated in 3 estates in the Kurunegala district to study the effect of mass release of *N. baraki* in the field to control coconut mite. Two 1 ac. plots were selected from each estate. In each plot 20 coconut mite infested palms were selected and on 8 randomly selected palms received 5000 *N. baraki* per palm was released on 3rd, 4th and 5th bunches. Before releasing the predatory mites, one pre-release sample was collected (one week before the first release), 1 nut from the 4 or 5-month old bunch of each palm that received predatory mites, adjoining palms to the released palms and the control palms (palms that did not receive predatory mites). After releasing predatory mites, 1 nut from 4 or 5-month old bunch of the released and 12 adjoining palms were sampled at 1 week after release, 2 weeks after release and once a month thereafter. Total number of eggs and other stages of predatory mites were counted.

The effect of releasing *N. baraki* is not clearly reflected in the pest population. However, it is expected to collect yield data for further evaluations. The study is in progress.

*N. S. Aratchige, K. F. G. Perera, P. H. P. R. de Silva,
C. Wijesinghe, N. Wijesinghe & C. Hettiarachchi*

Experiment 27.53 Survey to determine distribution of *N. baraki* and *N. paspalivorus* in different agro-climatic zones (2004)

A study initiated to determine the distribution of *N. baraki* and *N. paspalivorus* in different agro-climatic regions over time was continued. The results indicated that *N. baraki* is the most abundant species. *N. baraki* was distributed in all infested areas, but in varying proportions with *N. paspalivorus*. It occurs at a higher proportion in dry zone, while *N. paspalivorus* was mainly confined to wet zone and found there at higher proportions. In the intermediate zone both species occurred almost equally (Table 2). Interestingly, *N. paspalivorus* was also found in isolated pockets closer to water bodies such as lakes and irrigation channels in the dry zone (e.g. Tissamaharama, Dambulla, Iginiyagala). In the intermediate zone both species occurred. In the areas where both species were recorded they were found in the same plantation and occasionally on the same nut. The study is in being continued.

Table 2. Distribution of *N. baraki* and *N. paspalivorus* in different areas of Sri Lanka in 2005-2006

Climatic zone	District	Area	Percent incidence	
			<i>N. baraki</i>	<i>N. paspalivorus</i>
Dry zone	Puttalam	Kalpitiya	100	0
Dry zone	Puttalam	Madurankuliya	100	0
Dry zone	Anuradhapura	Rajangane	100	0
Dry zone	Polonnaruwa	Polonnaruwa	100	0
Dry zone	Polonnaruwa	Maduru-oya	100	0
Dry zone	Ampara	Kohobana	100	0
Dry zone	Ampara	Nintavur	100	0

Dry zone	Ampara	Inginiyagala	81.6	18.4
Dry zone	Hambantota	Tissamaharama	6.6	93.4
Dry zone	Matale	Dambulla	82.2	17.4
Dry zone	Puttalam	Madampe	48.6	51.4
Intermediate zone	Kurunegala	Ganewatte	98.0	2.0
Intermediate zone	Kurunegala	Narammala	85.8	14.2
Intermediate zone	Kurunegala	Makandura	53.0	47.0
Wet zone	Gampaha	Mirigama	10.6	89.4
Wet zone	Gampaha	Weliweriya	6.4	93.6

L. C. P. Fernando, S. Mayadunne, R. Dissanayake, A. D. N. T. Kumara,
N. Ekneligoda, C. Wijesinghe & N.G. Premasiri

Experiment 27.73 Survey for predators associated with *Dolicoetranychus nr sp. cocos* and *Colomerus novahebridensis* (2006)

D. nr sp. cocos and *C. novahebridensis* are two mite species, inhabiting under the perianth of coconut as coconut mite. These mite species cause scarring similar to that of *A. guerreronis*, but damage is mild due to their low numbers. These low numbers of the pest could be due to the presence of effective predators, which could also be used in management of coconut mite. Therefore, a survey was carried out to identify these predators. A total of 11 areas with no coconut mite infestation were selected for the survey. Thirty palms were selected randomly in each location and one 8-month old nut, which showed symptoms of damage, was picked from each palm. The nuts were categorized according to the type of damage and the total number of each kind of predatory mite was counted under a stereo microscope.

N. baraki and *N. paspalivorus* were the two species associated with *D. nr sp. cocos* and *C. novahebridensis*. Few other species of insects and mites were rarely observed on the nuts. *N. baraki* was found only in Embilipitiya associated with *D. nr sp. cocos*. In all other areas *N. paspalivorus* was found, but their numbers on a nut was low. *N. paspalivorus* was mostly found associated with *D. nr sp. cocos* than with *C. novahebridensis* (Table 3). Higher abundance of *N. paspalivorus* on the nuts infested by these two species may be that these species are more prevalent in the cooler and wetter areas, which is also preferred by *N. paspalivorus*. The presence of both *Neoseiulus* spp. in areas where coconut mite was not found indicates that these species might have been present in the country before coconut mite was invaded. Further, it suggests that these species might have moved on to coconut mite from nuts infested by *D. nr sp. cocos* and *C. novahebridensis*.

N. I. Suwandhrathne, L. C. P. Fernando, S. Mayadunne,
N. Ekneligoda, L. Liyanage & N. G. Premasiri

Table 3. *Total number of N. baraki (N.b) and N. paspalivorus (N.p) found on 30 nuts infested by D. nr sp. cocos (A) and C. novahebridensis (B) in each area.*

Province	Area	With A		With B		With A+B	
		<i>N. b</i>	<i>N. p</i>	<i>N. b</i>	<i>N. p</i>	<i>N. b</i>	<i>N. p</i>
Western	Colombo	0	2	0	0	0	5
	Kalutara	0	23	0	0	0	6
Central	Matale	0	9	0	0	0	9
	Kandy	0	8	0	0	0	1
Southern	Matara	0	12	0	0	0	0
	Galle	0	14	0	2	0	0
Sabaragamuwa	Middeniya	0	23	0	2	0	0
	Ratnapura	0	11	0	2	0	6
	Kegalle	0	6	0	1	0	12
Uva	Embilipitiya	4	6	0	1	0	0
	Monaragala	0	0	0	0	0	4

Experiment 27.63 Determination of frequency of application of *H. thompsonii* in the field (2005)

A study commenced to determine the suitable frequency of application of the isolate H/2 was continued in 2 sites at Ariyagama (intermediate zone) and Manchadi estate (dry zone). The site in Chilaw (Martin Farm) was discontinued as sufficient number of nuts for sampling could not be found. The spraying at both estates was completed after one year.

The mean number of coconut mites varied over time in both estates (Figs. 10 & 11). At Manchadi estate there was a significant difference among the treatments with respect to mean number of coconut mites ($p < 0.001$) (Covariate analysis). However, the mean numbers for the 9-month period between 2-monthly (900.6) and 3-monthly (829.6) were not significantly different and significantly lower than the control (1106.6). At Ariyagama there was no difference in the mean number of coconut mites among the treatments (1169.3, 1319.7 and 1265.1 in 2-, 3-monthly and control respectively). The fungus persisted throughout the experimental period on treated palms in both sites.

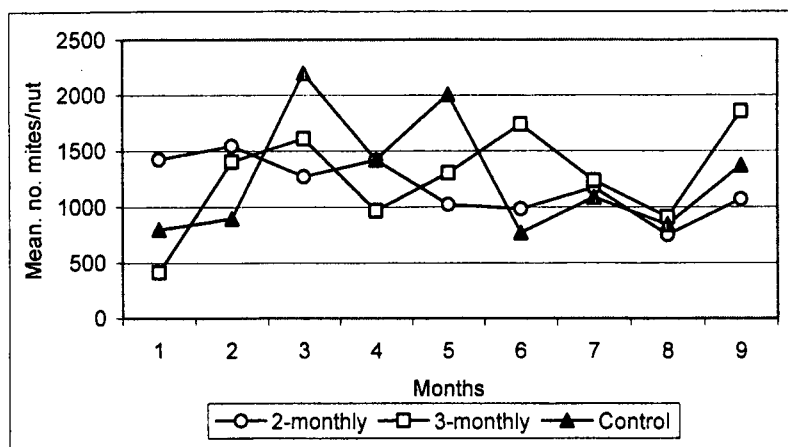


Figure. 10. *Adjusted mean number of coconut mites on nuts treated at different intervals in Manchadi estate*

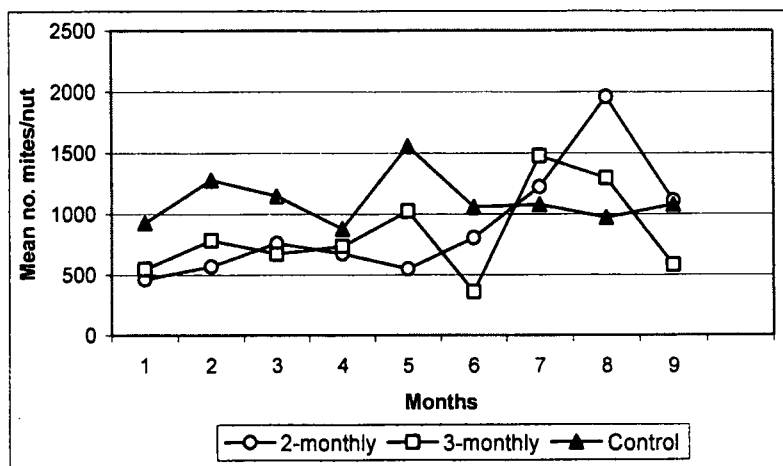


Figure. 11. *Adjusted mean number of coconut mites on nuts treated at different intervals at Ariyagama*

Assessment of damage on the harvested nuts was commenced and being continued. The nuts were categorized as undamaged, damage-discontinued, damage-continued, damaged & smaller size, damaged & deformed and other nuts. At Manchadi estate there was no difference between the proportions of undamaged nuts in treated and untreated blocks, but the proportion of damaged & smaller size nuts was less in treated block than in the untreated block (Fig. 12). At Ariyagama, the proportions of undamaged nuts were very high in the treated palms than on the untreated palms (Fig. 13). But the proportion of damaged & smaller sized nuts was higher in the treatments at many occasions. The results suggest that treatments reduce the coconut mite damage although the results of coconut mite numbers were erratic. The study is in progress.

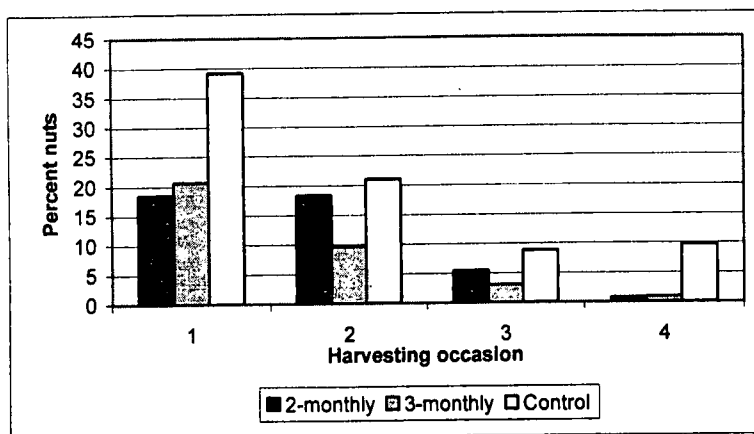


Figure.12. Proportion of damaged & smaller sized nuts in 2-monthly and 3-monthly application of *H. thompsonii* at different harvesting occasions at Manchadi estate in 2006

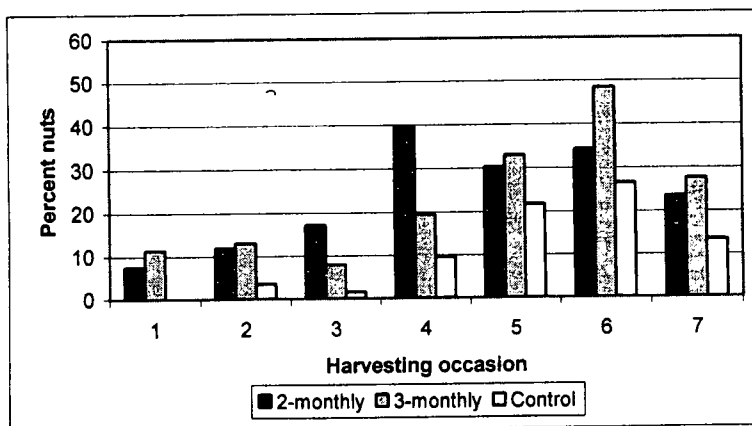


Figure 13. Proportion of undamaged nuts in 2-monthly and 3-monthly application of *H. thompsonii* at different harvesting occasions at Ariyagama in 2006

L. C. P. Fernando, D. C. L. Hapuarachchi, C. Senarathne,
P. Damayanthi & S. Wijekoon

Experiment 27.74 Determination of the effectiveness of *H. thompsonii* cultured on liquid medium (2006)

Although spraying of the fungus grown on rice medium (solid) have shown to be effective in reducing damage of coconut mite, due to the bulkiness in production and storage and difficulties in extraction of spores it was envisaged to determine the effectiveness of the liquid medium on coconut mite. The liquid medium just after shaking predominantly produces mycelium while the same kept in still conditions for 7 days produces both mycelium and spores. A study was conducted to compare the effectiveness of the fungus grown on liquid culture

medium with that of the solid (rice) medium in two sites viz Bandirippuwa estate and Makandura Seed Garden (MSG) (intermediate zone) and at Tharawilluwa (dry zone). Three spray treatments; liquid medium (mycelium only), liquid medium-still (mycelium and spores), solid medium (spores and mycelium) were carried out. The spray concentration for each treatment was $1 \times 10^6 - 1 \times 10^7 \text{ ml}^{-1}$ CFU and the treatment was carried out twice at 2 weeks apart. Ten coconut mite infested palms were used for each treatment including the untreated control at each estate. One of 4-month old nut was picked from each palm before the treatment and at different intervals after treatment and assessed the total number of mites.

The adjusted mean number of total mites in different treatments varied at each site over time (Figs. 14, 15 & 16). The results indicated that there were significant differences in the adjusted mean number of total mites among treatments at all sites (Bandirippuwa estate $p < 0.001$, MSG $p < 0.001$ and Tharavilluwa $p < 0.05$). At all 3 there were no significant differences in the mean number of coconut mites between solid medium and liquid culture-still medium suggesting that liquid culture-still medium is equally effective as the solid medium. However, untreated palms had the highest number of mites than all other treatments. It was also indicated that the fungus persisted on the treated palms up to 2 months in all sites.

L. C. P. Fernando, D. C. L. Hapuarachchi,
C. Senarathne & P. Damayanthi

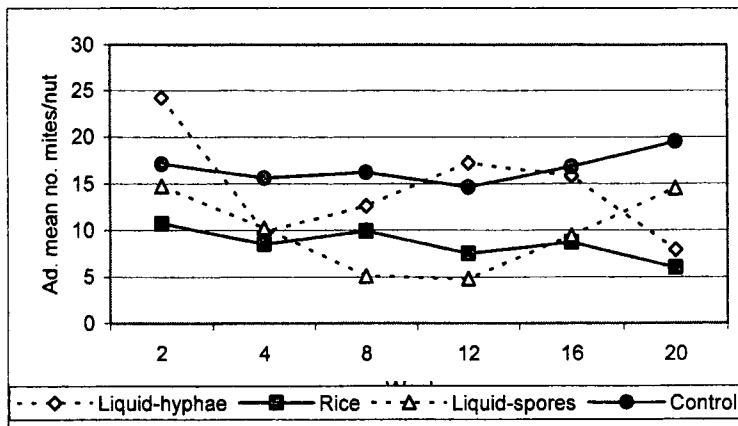


Figure. 14. Mean number of coconut mites in different treatments with *H. thompsonii* at Bandirippuwa estate

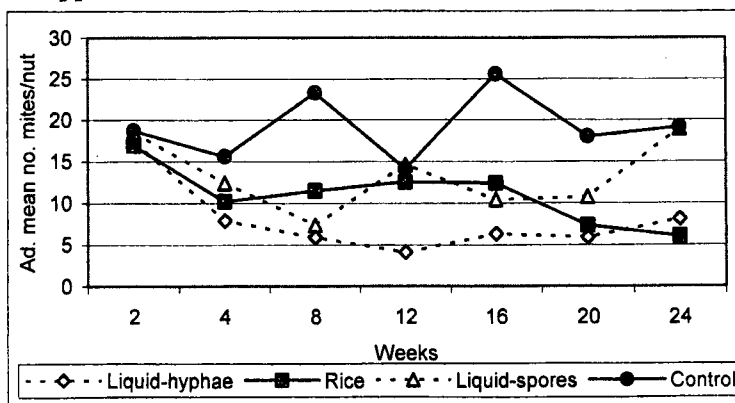


Figure 15. Mean number of coconut mites in different treatments with *H. thompsonii* at Makandura Seed Garden

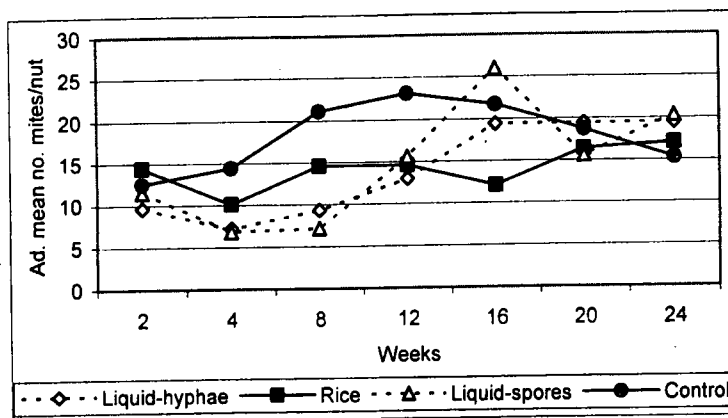


Figure 16. Mean number of coconut mites in different treatments with *H. thompsonii* at Tharawilluwa

Experiment 27.65 Effect of spraying a mixture of palm oil and sulphur for the management of coconut mite (2005)

In a previous study, it was confirmed that spraying a mixture of 20% palm oil and 0.05% wettable sulphur effectively reduces the coconut mite population. Therefore, a pilot trial was commenced in 4 estates to confirm its effectiveness and to quantify the reduction in damage. One acre blocks (app. 60 palms) at Hettipola, Kobeigane, Nikadalupotha and Nattandiya were treated with the mixture. At Nikadalupotha and Nattandiya each of 30 palms will be treated at 3 monthly and 6 monthly intervals, while the blocks in Hettipola and Kobeigane were treated once. One round of spraying was conducted in all estates. From each block 20 palms were selected and damage assessments in 3 and 4-month old bunches were taken at 3-monthly intervals.

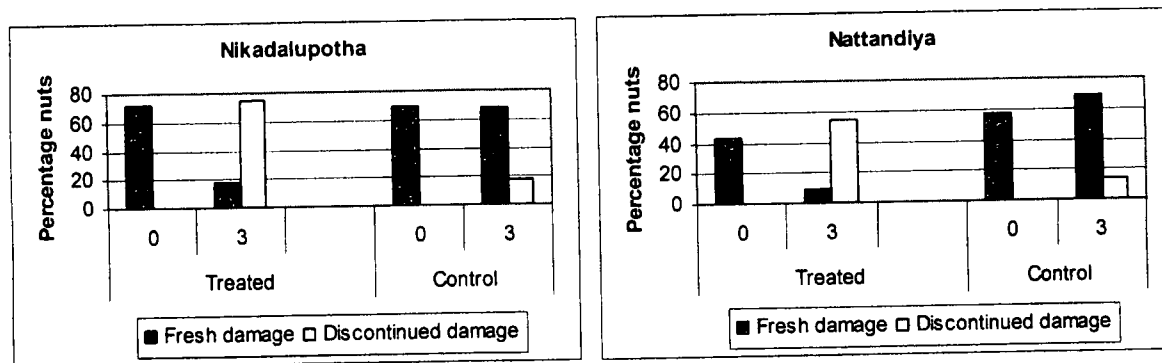


Figure 17. Percentage nuts with fresh and discontinued damage on the 4-month old bunch prior to treatment and 3 months after treatment at Nikadalupotha and Nattandiya

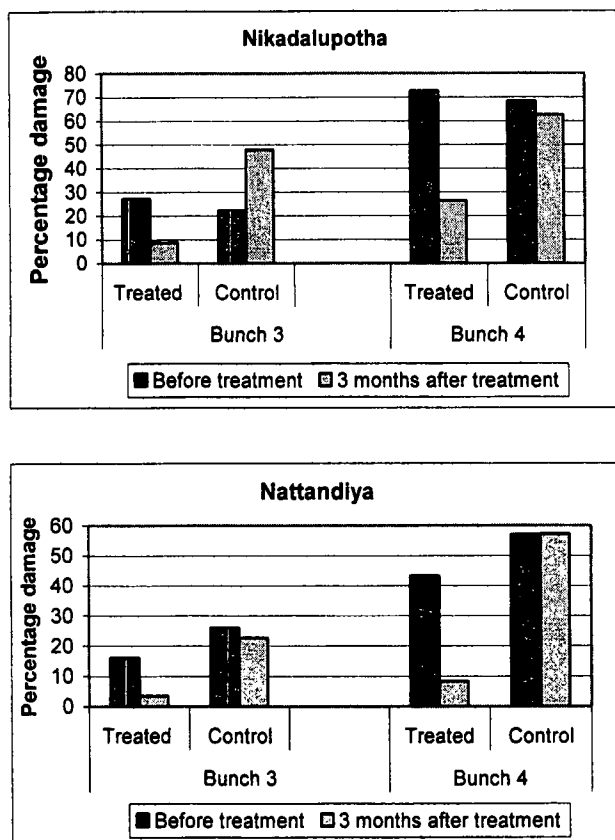


Figure 18. *Percentage of damaged nuts on 3- and 4-month old bunches at the time of treatment and 3 months after treatment at Nikadalupotha and Nattandiya*

The results indicated that 3 months after application the damage on a high proportion of infested nuts have been discontinued and the percentage of fresh damage have been reduced significantly on treated bunches (Fig. 17). Further, the results indicated that percentage of damage on newly developing 3-month and 4-month old bunches have greatly reduced due to the treatment than that present at the time of treatment (Fig. 18). In contrast, the percentage damage on untreated nuts has increased in 3 months. The study is in progress.

L. C. P. Fernando & K. A. S. Chandrasiri

Experiment 26.75. Screening of Neem granule and NeemAzal 1% against coconut mite (2006)

Evaluation of the effect of different doses of neem based granules (Azadirachtin 1500ppm) and NeemAzal 1% (Azadirachtin 1%) on 15-20 years old palms in two estates at Wallawe and Heraliyawala in the Kurunegala District (North-western Province) was commenced. In each estate, 5 treatments were done on each of 6 randomly selected palms at three monthly intervals. The treatments were soil application of neem granules (1500ppm) at doses of 80g, 100g and 120g per palm, spraying of NeemAzal 1% (5ml/palm) and untreated control. The damage on 3, 5 and 7-month old bunches of each palm and the total number of

mites per nut was recorded prior to treatments and at 3-monthly intervals and monthly intervals afterwards respectively. The study is being continued.

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Experiment 26.76. Screening of Neemraj Supreme against coconut mite (2006)

Evaluation of the effect of root feeding of Neemraj supreme (Azadirachtin 10000ppm) against coconut mite in four estates at Mundel, Mangalaeliya, Rajakadaluwa and Pallama in the Puttlam District was commenced. In each estate 30, coconut mite infested palms were selected randomly and treated with 10ml Neemraj + 10 ml water by root feeding at 3-monthly intervals. Another 30 palms were kept as untreated control. The total population levels of coconut mite were assessed at monthly intervals and the damage on 3, 5 and 7-month old bunches were recorded at 3-monthly intervals. The pick records were taken to assess impact of the treatment on damage levels. The study is being continued.

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Experiment 27.77 Evaluation of the resistance/tolerance level of parental material at Ambakelle Seed Garden for coconut mite (2005)

In the previous year it was shown that yellow dwarf (DY) was more tolerant than green dwarf (DG) and tall to coconut mite damage. Since there are some morphological differences within DY form, based on morphology of the palm the entire dwarf yellow population has been classified in to three groups. In order to find out whether there will be a difference in mite incidence among these three groups, an assessment was initiated using the index developed for assessing the mite incidence in palms.

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Experiment 26.78 Screening of three coconut varieties for coconut mite tolerance in Bandirippuwa estate

In the previous year it was evident that the tall yellow color form, Gon Tembili had a lower incidence of symptoms initiation and subsequent symptom expression. In order to assess the mite incidence in infested palms, an index was developed to assess the status of the palm from the ground. In this method the damage severity was measured in two steps. First an index was given to the palm based on the proportion of bunches with mite damage. Then the relative damage within a bunch (observing all bunches likely to have damage) was indexed considering number of nuts affected within the bunch and the severity of infestation. Final mite index of the palm was obtained by getting the product of the two indices (Table 4). This was a relative judgment but it provided a good categorization of the palms with different levels of damage in to different groups (Range 1-16).

Table 4. *Index to assess the mite incidence in infested palms*

Percentage bunches affected	Palm index	Severity of damage in bunches	Bunch index	Mite index = Palm index X Bunch index
0-25	1	0-25	1	
>25-50	2	>25-50	2	
>50-75	3	>50-75	3	
>75-100	4	>75-100	4	

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Experiment 26.79. Screening of four coconut cultivars for tolerance against coconut mite Ratmalagara Estate (2006)

Four crosses that have been established as observational plots at Ratmalagara Estate Madampe were in the mite infested blocks but the incidence has been low. The crosses are Dwarf Yellow X San Ramon, Dwarf Green X san Ramon, Dwarf Green X Tall and Dwarf Green X san Ramon. A study was initiated to assess the mite incidence of these four cultivars in comparison with the ordinary tall plantation in an adjacent block. The mite index and the harvest record are being recorded.

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Experiment 27.80 Screening of improved cultivars for resistance/tolerance against coconut mite (2006)

A study was commenced to study the tolerance of three improved cultivars out of the five at Tammennawa Estate, Puttalam. The varieties selected were Dwarf Yellow X Tall (DYT), Dwarf green X Tall (DGT) and Tall X Tall (TT). Since there was a belief that the tall colour form "Rethi" (reddish color form) shows some tolerance to coconut mite, a group of 20 palms were also selected from a nearby plantation. Total coconut mite population on a nut, damage assessment in the 4-month old bunch in 3 subsequent months and crop loss at harvest were recorded. Two characters, shape as measured by length to breadth ratio and the perianth to the nut surface that would lead to the tolerance were investigated.

There was a significant difference ($P < 0.05$) in the total coconut mite population among the four cultivars during the first and second months but not in the third month. The lowest level of population among the four cultivars was obtained in DYT but according to Duncan's multiple range test procedure, significant differences were observed only in the first and the second months. TT had the highest population at all times but a significant difference between DGT and TR was observed only in the first month (Table 5).

Table 5. *Mean total population of coconut mite on 4-month old nuts in different cultivars*

Cultivar	1 st month	2 nd month	3 rd month	Number of nuts observed
Dwarf yellow x Tall	70.5C	76.5B	310.5A	20
Dwarf green x Tall	213.0B	298.5A	438.0A	20
Tall x Tall	535.5A	477.0A	547.5A	20
Tall "Rathi"	364.5AB	310.5A	520.5A	20
Coefficient of Variance	76.6	79.6	62.3	
Coefficient of correlation (R ²)	0.24	0.24	0.23	

Means with the same letter in a column are not significantly different

A similar variation was observed in the percentage damaged nuts. A significant difference ($P < 0.05$) in the percentage of damaged nuts among the four cultivars was observed during the first and second months but not in the third month. The lowest damage was recorded in DYT. The other three cultivars had no difference at any time (Table 6).

Table 6. *Percentage of damaged nuts on the 4-month old bunch in different cultivars*

Cultivar	1 st month	2 nd month	3 rd month	Number of nuts observed
Dwarf yellow x Tall	9.10 ^B	05.25 ^B	28.30 ^A	20
Dwarf green x Tall	37.92 ^A	19.79 ^A	41.91 ^A	20
Tall x Tall	42.71 ^A	37.80 ^A	46.02 ^A	20
Tall "Rathi"	29.23 ^A	28.04 ^A	27.15 ^A	20
Coefficient of Variance	74.16	77.79	62.59	
Coefficient of correlation (R ²)	0.19	0.24	0.058	

Means with the same letter are not significantly different

Percentages crop loss due to mite damage at harvest

The percentage crop loss at harvest was analyzed using ANOVA procedure. A significant difference ($P < 0.05$) among the four cultivars was evident and the Duncan's multiple range test clearly indicated that the lowest mean crop loss was in the cultivar DYT (Fig. 19).

The study indicated that the mean total coconut mite population levels, damage initiation, and the crop loss due to mite damage were least in DYT and hence had the highest tolerance to coconut mite. The tolerance level decreased in the order of DGT, TR and TT respectively.

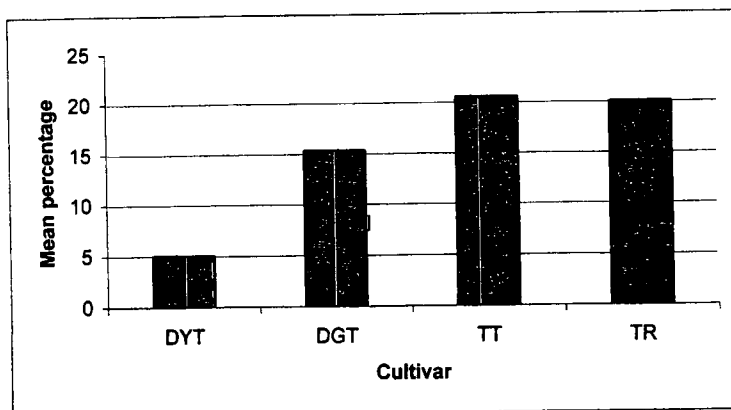


Figure 19. Mean percentage crop loss in the four cultivars

Distance between nut surface and the perianth of the nuts

The mean distance between nut surface and the perianth of the four cultivars was analyzed using ANOVA procedure. The differences of mean values were highly significant among the four cultivars. The means were then separated using Duncan's multiple range tests. The cultivar, DYT had the lowest distance (Table 7) but was statistically significant only in the second and third months.

Table 7. Mean distance (μm) between nut surface and perianth

Cultivar	1 st month	2 nd month	3 rd month	Number of nuts observed
DY×T	13.438 ^C	10.718 ^C	9.125 ^C	20
DG×T	19.406 ^A	19.375 ^A	18.906 ^A	20
T×T	16.063 ^B	18.141 ^A	17.313 ^B	20
TR	14.813 ^{BC}	15.531 ^B	15.438 ^B	20
Coefficient of variance	20.48	23.89	31.46	
Coefficient of correlation (R^2)	0.3258	0.4399	0.3883	

Length: width ratio of the nuts

Results of this study clearly indicated a significant difference between the four cultivars in the ratio of length and width of the nuts in the third bunch. DYT had the lowest ratio at all times but the significance varied at different months (Table 8).

Table 8. Mean length to width ratio of the nuts of four cultivars

Cultivar	1 st month	2 nd month	3 rd month	Number of nuts observed
DY×T	1.34090 ^B	1.34360 ^B	1.51357 ^B	20
DG×T	1.38675 ^{BA}	1.42439 ^B	1.58835 ^{BA}	20
T×T	1.36464 ^{BA}	1.60856 ^A	1.60856 ^A	20
TR	1.45458 ^A	1.58835 ^A	1.66520 ^A	20
Coefficient of variance	10.96	9.69	8.41	
Coefficient of correlation (R ²)	0.0757	0.3836	0.1470	

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Experiment 27.30 Development of a digital imaging method for assessing populations of coconut mite on nuts

With the objective of making the counting of coconut mites on a nut easier, a method was developed using a digital image processing system. The method was further improved by using a computer-based package which enabled fully automated counting.

The bracts of a coconut mite infested nut were removed and the coconut mites on bracts and nut surface were washed in to a mild detergent solution. The wash sample was allowed to stand for 1 h to make the mites float on the wash surface. An image of the coconut mites floating on the surface was obtained using a digital still camera (Canon Power shot S 50). The image was imported to Arcsoft Photo Studio and the number of mites in the image was counted manually. To improve the clarity of the image a drop of ink was added to stain the wash solution before counting.

It was evident that not all the coconut mites float on the surface of the wash solution by standing it even for 2 h. Attempts were made to obtain as many coconut mites as possible on to the surface by increasing the density of the solution failed. Therefore, it was decided to count the number of mites in a 1 ml sample placed on small dish (2 cm diameter) of the total wash.

To determine the possibility of counting the number of live and dead coconut mites in a colony of 2 cm area on the nut surfaces images were taken. Since it was not possible to separate out live and dead coconut mites in the image either the live or dead mites (which ever was low in number and hence easier) was counted manually before obtaining the image. The total number of coconut mites in the image was counted and the live and dead numbers were determined separately.

Development of a software for counting the mites captured by the digital camera was accomplished by developing algorithms on Matlab platform. The final program to count the number of coconut mites was developed as an individual package that can be executed on any

common computer Operating System, without the use of Matlab. Mite counting can be done with the use of the computer and already available display techniques. A 'mean' color of the objects (mites) was selected by user before segmentation. As this may not give an optimal result due to non- prominent variation of color between objects and background adding of contrasting color to background was done to improve the result.

The image of coconut mites on the surface of the wash solution was successfully transferred to a computer image using the digital camera and the number of mites displayed on the computer screen was conveniently counted manually. Adding of ink in to the wash solution improved the image on the screen and made manual counting easier. Although it was possible to count the number of mites on the surface of the wash solution in an image taken by the camera, it was revealed that all the coconut mites do not float on the nut surface and increasing the density of the solution does not help to improve this number. Therefore, this method of sample preparation was not suitable to count the coconut mites in the image.

The image of the nut surface was captured successfully. Although it was not possible to separate the live and dead coconut mites in the image, it was possible to determine those numbers separately by counting the number of live or dead coconut mites prior to obtaining the image.

A software was developed to automate the counting of mites at the computer. There was a small variation between the manual counting and the automated counting but it was not statistically significant ($p > 0.05$) (Table 9). This was a very efficient method of determining the total number of coconut mites on the surface of the wash opposed to adhering to the tedious microscopic counting. Further a large number of samples could be processed at a short period. However, the method of sample preparation for the image capturing needs to be improved.

Table 9. Numbers of coconut mites counted manually and using the computer package in four different captures

Sample	Manual count	Automated count
Capture 1	295	282
Capture 2	275	285
Capture 3	292	304
Capture 4	315	323

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PROJECT 26**IMPROVEMENT OF THE ELECTRONIC DEVICE TO DETECT RED WEEVIL INFESTED PALMS (1998)****Experiment 26.2 Improvement of the electronic device to detect red weevil infested palms (2005)**

A user friendly and an effective electronic device to detect red weevil infested palms were developed. Field-testing of the device for reliability and efficiency of use was commenced.

In infested plantations, an infested block was selected and each palm was checked. The sensor of the device was placed at 4 positions, either sides on the palm base (A and B) and bases of 2 lowermost fronds (C and D) and recorded whether crunching sound was present or absent at each position. The palms having symptoms and not detected and palms with no symptoms but detected were rechecked after one month. Generally, infested palms show external symptoms. However, if the infestation is at very early stages symptoms may not be observed. Also, in the palms that symptoms were observed, larvae may not be present if pest is in the pupal stage or the infestation was too old, hence the sound may not be detected. It was not possible to cut and examine such palms.

The results in the first observation indicated that the probability of correctly detecting the infested palms was highest when the sensor was placed in all 4 positions (Table 10). At these positions 93.1% of the palms with damage symptoms were detected as infested (crunching sound present). Also, 94.1% of palms which did not have damage symptoms were not detected as infested (no crunching sound). Two percent of the palms (2 palms) that had symptoms and were not detected as infested were detected in the second observation increasing the accuracy of detecting infested palms from 93.1% to 100%. Also, out of 5.9% palms (27 palms) that had no damage symptoms, but detected as infested in the first observation 20 palms were confirmed not infested increasing the accuracy in confirming non infested palms from 94.1% to 98.6%. Ants present in uninfested palms depict the crunching sound and could lead to wrong diagnosis. Hence, the results revealed that the device is over 93% accurate at the first observation and it could be increased up to 98% by a subsequent observation after one month. The study is being continued.

Table 10. *Probability of correctly detecting infested palms (symptoms present) and probable uninfested palms (symptoms absent) at different positions on palms with and without damage symptoms at the first observation*

Position	Symptoms present	Symptoms absent
A	65.5	97.7
B	66.7	98.1
C	41.7	97.9
D	27.6	97.3
A and B	65.5	97.1
C and D	41.3	96.6
A, B, C and D	93.1	94.1

L. C. P. Fernando, K. F. G. Perera, A. D. N. T. Kumara, Dr. N. Nanayakkara & K. A. P. Siriwardena (Rinzen Laboratories)

PROJECT B26.5 STUDIES ON THE CONTROL OF LEAF ROT DISEASE OF COCONUT (2000)

Experiment B26.5.5 Survey on leaf rot disease in the Southern Province (2005)

The survey initiated to determine the disease severity of the leaf rot disease and the factors associated with the disease incidence in four Coconut Development Officer (CDO) ranges namely Ahangama, Dikwella, Matara and Weligama was completed. Out of all coconut holdings in the CDO ranges 1% was randomly chosen for the study. It included 97 coconut holdings covering a total of 279.25ac. distributed in Ahangama (3.06ac.), Dikwella (135ac.), Matara (10.11ac.) and Weligama (131.07ac.) ranges. Highest percentage of diseased palms (30.6%) was reported from Weligama area (Table 5). Matara had the highest percentage of severely affected palms (48.8%) and Ahangama (10.2%) had the lowest. Many dead palms in Weligama area was reported while no casualties have been reported from Ahangama (Table 11).

The survey revealed that there was no relationship between disease incidence and the coconut variety. The percentage of land owners who applied fertilizer was 17.5% and 29.4% of them apply 3 kg. Only 5.2% of the land owners have applied dolomite. Mulching was practiced by 21.7% growers. A grower in Weligama has noticed leaf rot disease as early as 1990 while 4.1% of growers have noticed the disease 10 years ago. Rest of the growers (95%) has noticed disease after 2000. Thirty two percent growers have applied the fungicide Folicur, which was provided by the Coconut Cultivation Board at the rate of 4ml/ 1/ palm. But no one has attempted to repeat the fungicide treatment, except one grower. Twenty nine percent of the growers who have applied fungicide have observed recovery of the disease after one application. Palms in 80% of the lands showed nutrient deficiency symptoms.

Table 11. Number of holdings and extent (ac.) surveyed and the number of leaf rot affected palms in four CDO ranges

CDO range	No of holdings	Extent & Total no. palms ^a	No. of affected palms & % from total affected palms (in parenthesis)				
			Total no. & percentage ^b	Mild	Moderate	Severe	Dead
Ahangama	4	3.1 (160)	49 (30.6)	24 (48.9)	20 (40.8)	5 (10.2)	00
Dickwella	2	135 (7259)	119 (1.6)	55 (46.22)	49 (41.2)	15 (12.61)	03
Matara	35	10.1 (256)	41 (16.0)	11 (26.8)	10 (24.3)	20 (48.8)	31
Weligama	55	131.1 (6329)	677 (10.7)	367 (54.2)	231 (34.1)	79 (11.7)	79

^a - in parentheses, ^b - percentage from total number of palms

H. T. R. Wijesekara, Liyanarachchi & N. G. Premasiri

Experiment B26.5.6. Studies on the effect of nutritional condition on leaf rot affected palms (2006)

An experiment was commenced to study the effect of palm nutrition on leaf rot affected palms in three sites, namely Batadola watta, Pathegama, Medahena watta, Dandeniya and Abensuhena watta at Kamburugamuwa. Each of 6 affected palms in mild and moderate stages and 6 healthy palms of similar age were selected to represent soil classes S2, S3 and S4. Forty kg. of compost were applied into a half circle trench around the palms in addition to the normal fertilizer dose. Disease condition (total number of affected fronds, onset tapering, number of nuts in bunches, extent of leaf rotting) of the palms was recorded at 3-monthly intervals. Leaf and soil samples were obtained from affected and healthy palms for the analysis of nutrients prior to the application of treatments. Isolations were performed from affected tissues and pure cultures of the fungi were obtained. One round of compost application was completed.

Leaf analysis indicated that both healthy and affected palms are deficient in potash, magnesium, calcium, sodium, manganese and zinc (Table 12). Phosphorus and Copper levels in both categories exceeded that of sufficiency range.

Table 12. Results of leaf analysis for nutrients of leaf rot-affected and healthy palms in three experimental sites irrespective of soil class

Category	%N	%P	%K	%Mg	%Ca	%N a	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Affected	2.18	0.19	1.87	0.34	0.38	0.26	79.55	203.4	14.76	32.9
Healthy	2.16	0.8	1.04	0.28	0.34	0.13	111.05	223.0	12.06	38.4
Sufficiency- range	1.9- 2.1 (2.0)	0.11- 0.13 (0.12)	1.2- 1.5 (1.3 5)	0.25- 0.35 (0.3 5)	0.35- 0.5 (0.42 5)	0.4	40.0	60.0	5.0	30

Average values are given in the parentheses

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PROJECT 27 SCREENING OF INSECTICIDES AGAINST COCOUT PESTS (2005)

Experiment 27.1 Evaluation of four insecticides as spray applications for the management of black beetle (2005)

Drenching of the recommended chemical for the management of black beetle, carbofuran on young palms requires climbing of the tree. This generally causes damage to leaf bases attracting red weevil subsequently. A study was commenced to determine whether the insecticides, dimethoate (4ml/l), Marshall SC (4ml/l) and chlorpyrifos (2-3ml/l) are effective in

managing black beetle when treated as a spray. The insecticides were evaluated along with carbofuran by drenching (15g per seedling) in 2 estates. For evaluating dimethoate 66 black beetle damaged seedlings were selected while 50 similar seedlings were used as the untreated control in one estate. In the other estate, each of 40 black beetle affected seedlings were used for spraying chemicals while another 40 was kept as control. Spraying was done at 2-monthly intervals and the damage assessments on the newly opened fronds were taken at 4-monthly intervals.

The results showed that the percentage of freshly affected fronds declined steadily in carbofuran treated palms (Table 13). There was a decline in damaged fronds in palms treated with dimethoate compared to the untreated palms, but other two chemicals did not give considerable reduction in damage compared to the untreated control. Spraying of dimethoate at 2-monthly intervals could be recommended. The advantage of this method over drenching of carbofuran is that the young palms need not to be climbed for the treatment, which damages the bases of fronds attracting red weevil subsequently.

Table 13. *Percentage of freshly damaged fronds in different treatments at 3 monthly intervals*

Treatment	Percentage of fronds at different times (months)			
	3	6	9	12
Dimethoate 40%	32	44	23	23
Control	48	55	39	80
Marshal 20EC	43	60	34	40
Chlorpyrifos 40	63	76	31	36
Carbofuran 3g	47	38	21	8
Control	69	77	49	34

L. C. P. Fernando & K. A. S. Chandrasiri

PROJECT 28 DEVELOPMENT AND FIELD-TESTING OF INTEGRATED PEST MANAGEMENT STRATEGIES FOR *ORYCTES RHINOCEROS*

Experiment 28.1 Field testing of Integrated Pest Management Strategies for *Oryctes rhinoceros*

Six treatments; integration of *Oryctes virus* (*OrV*) + Green Muscardine Fungus (GMF) + Attractant baited traps (pheromone), GMF + *OrV*, GMF, *OrV*, Pheromone traps and untreated control were commenced in plantations having moderate-severe *Oryctes rhinoceros* damage. Each treatment was replicated thrice and each replicate consisted of one ha area of coconut. The following sites were selected for the treatments; *OrV* + GMF + pheromone in Andigama farm, Bandirippuwa estate, Horakelle farm, GMF + *OrV* in Dias watta, Galmuruwa, Lechchamy estate, GMF in Asanakotuwa, Loluwagoda, Moonamaldeniya, *OrV* in Dematpitiya watta, Samagi Estate, Siyambalagas watta, pheromone traps in Annadale estate, Govinda watta,

Madawalagara watta, and control in Henegedera, Nimroth watta, Tabbowa. In the center of each block, 15 palms were randomly selected to record the fresh bud damage and at each assessment occasion the bud leaf of each palm was marked for easy assessment of damage at the subsequent turn. The log traps with GMF were examined at 3-monthly intervals and adult and other stages of *Oryctes rhinoceros* beetles were recorded. The pheromone traps were examined at monthly intervals and the beetles collected were dissected to determine *ORV* infection.

Very few larvae were found in pheromone traps while, a considerable number of eggs and large number of adults were collected (Table 14). The percentage of *ORV* infection in black beetle population in the six sites where pheromone baited traps were installed is shown in Table 15. There infection rate increased over time in all sites irrespective of whether virus infected beetles were released or not. Virus incidence has particularly increased towards the rainy period and in wetter areas.

Table 14. Number of different stages of black beetle found in pheromone-baited traps in experimental sites during a period of one year.

Site	Eggs	Larvae	Adults	
			male	female
Annadale Estate	12	6	398	414
Andigama farm	57	1	653	668
Bandirippuwa estate	25	6	520	523
Govinda watta	23	3	642	591
Horakelle farm	113	16	577	614
Madawalagara estate	137	22	528	499

During the first three months, infection of GMF was not found in GMF traps as there were no larvae in them. Beetles tend to lay eggs when the saw dust is decaying, about 4 months after the installment of pits (Table 16). Hence, infection in larvae was found from the 6 months onwards (Table 17).

Table 15. Percent incidence of virus infection in *Oryctes rhinoceros* beetles caught in pheromone baited traps

Site	Percent infected beetles trapped in each month								
	1	2	3	4	5	6	7	8	9
Annadale estate	0	9	7	22	10	13	-	-	-
Andigama farm	5.0	11	13	17	-	-	-	-	-
Bandirippuwa estate	8	0	4	18	14	12	18	20	-
Horakelle farm	6	14	9	6	15	8	18	26	-
Govinda watta	14	7	7	12	13	8	27	0	13
Madawalagara estate	16	11	11	10	14	12	16	17	-

Table 16. Number of eggs, larvae, pupa and adults found in GMF pits during 2006

Treatment	Site	Eggs	Larvae	Infected larvae	Pupa	Adults
Integrated	Andigama farm	2	13	0	0	1
	Horakelle farm	115	88	4	0	1
OrV+GMF	Dias watta	0	0	0	0	0
	Galmuruwa watta	4	269	18	0	6
	Lechchami estate	69	65	0	0	0
GMF	Asanakotuwa	23	46	0	1	0
	Loluwagoda	8	14	0	0	2
	Moonamaldeniya	6	148	8	0	0

Table 17. Percent incidence of GMF infection in *Oryctes rhinoceros* larvae

Treatment	Percent incidence at 3-monthly intervals		
	1	2	3
GMF	0	4	0
GMF+Virus	0	1	45
Integrated	0	1	14
Control	0	0	-

The fresh black beetle damage was variable over time in different treatments. There was a decreasing trend in the treatments, ORV and pheromone traps (Table 18). The study is being continued.

Table 18. Percent *Oryctes rhinoceros* damage in experimental palms with respect to different treatments.

Treatment	Percent damage at 3 month interval			
	0	1	2	3
OrV+ GMF+Pheromone baited traps	65	49	38	87
GMF + OrV	53	29	67	47
GMF	62	57	75	53
OrV	69	62	51	33
Pheromone baited traps	82	82	73	57
Control	40	65	29	35

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Experiment 28.2 Natural Incidence of *Oryctes virus* disease of *Oryctes rhinoceros* in the Kurunegala District

The *Oryctes virus* (*ORV*) disease among populations of black beetles exists in Sri Lanka. Since its natural incidence has not been determined, a survey was conducted in Kurunegala district including 16 CDO ranges. One hectare of land area was selected in each CDO range and one each from two types of pheromone-baited traps was installed in each site. Bucket trap was hung on a wooden pole and the PVC tube trap was placed on ground. Beetles trapped in the traps were collected at two-weekly intervals for a period of 1 month. *ORV* diseases in the beetles were determined by dissecting the beetles and examination of the mid gut. In infected beetles mid gut appears swollen with a whitish fluid in it.

A total of 892 beetles (410 males and 482 females) were collected during the study period and 30.3% of the beetles were infected with the disease (Table 19). Out of them 32.2% of males and 28.6% of females were infected by the virus. Highest disease incidence of 40% was recorded in Ganewatta CDO range, whereas lowest of 20% was recorded in Kurunegala CDO range.

Table 19. Percentage *Oryctes virus* incidence among black beetle populations of different Coconut Development Officer ranges

CDO range	Number trapped	Percentage infection
Kurunegala	50	20
Dambedeniya	50	26
Narammala	50	30
Alawwa	52	38
Pothuhera	39	30
Mawathagama	48	37
Ganewatte	47	40
Ibbagamuwa	45	31
Bingiriya	98	22
Dummalasuriya	55	34
Hettipola	51	23
Kobeigane	63	22
Nikeweratiya	60	35
Pannala	66	30
Kuliyapitiya	52	38
Wariyapola	66	31
Total	892	30.3

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Experiment 28.3 Development of technologies for the mass production of green muscardine fungus, *Metarhizium anisopliae*

Two methods to produce the green muscardine fungus (GMF) in small scale by farmers were developed. They are production on maize grains and on *Oryctes* larvae. For both methods a local isolate of GMF collected from infected *O. rhinoceros* larva from the field was used. Mother culture of GMF was cultured and maintained on Saboraud Dextrose Agar.

1. Production on maize grains

The following materials are required; Broken maize grains (medium size), maize grains can be crushed either mechanically or manually by farmers depending on farmers resources, 12'x 6' sized poly propylene bags (gauge 150), pressure cooker/ steamer, GMF inoculum, pieces of PVC pipe (1'diameter and 1' length), surgical spirit, cotton wool (absorbent), rubber bands and candles

Step 1 - Preparation of bags of maize grains

Wash the crushed maize grains and drain off excess water. Fill polypropylene bags with 150-200 g of maize grains. Place PVC rings at the opened end of the bag using a rubber band. Plug the ring with cotton wool. Air in the bag should be removed as much as possible before plugging cotton wool.

Step 2 - Sterilization of bags containing maize grains

Two methods can be used depending on the resources of the farmer. Place bags containing maize grains in a pressure cooker/ a steamer and cook. a. in a pressure cooker for 1hour and 20minutes (at the pressure of 15 lbs per inch), b. in a steamer for 3 hours.

Step 3 - Inoculation of maize grains

The GMF inoculum (maize grains) will be provided to the farmers by the Coconut Research Institute. This step should be done on a clean table / bench in a clean room. First, wipe the table top with surgical spirit. Then fix 3 lighted candles on table in a half circle to create aseptic working area. Wash hands with soap and rub with surgical spirit. Wear a facemask and gloves. Open GMF inoculum on the aseptic source. Remove cotton plug of the sterilized maize bag removed using fingers while holding the bag. Put 1/5 of the GMF inoculum (approximately 15 g) in to the maize bag and return the plug. Massage the bags well to mix with GMF spores with the maize grain pieces. Keep the inoculated bags in a ventilated dark place for incubation. After 4-5 days white colour mycelium can be seen on maize and olive green colour spores appear on maize grains within 8-10 days.

2. Production on *Oryctes* larvae

The inoculum for inoculation of larvae is produced by the Coconut Research Institute and supplied to the growers.

Step 1

Allow *Oryctes* grubs to crawl in a small amount of inoculum (depending on the number of grubs) for 20-30 minutes to contact with GMF spores.

Step 2

Transfer infected grubs to clay pots filled with the breeding medium. The number of larvae per pot may depend on the size of the pot. Keep the medium moistened by adding water.

Step 3

The infected larvae will be dead in 2-3 weeks. The dead infected grubs (olive green colour) could be used as an inoculum source for re-infecting more grubs. One infected grub could be used to infect 5 healthy ones. Allow healthy grubs to contact with dead grubs for about 20 minutes and follow procedure as before.

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3. CROP PROTECTION SERVICES

Control of disease epidemics

a. A bud rot epidemic was reported in an estate at Uturawala. A total of 16 severely affected palms and 34 suspected palms with pale flaccid bud leaf were treated with a solution of Ridomil (3g/l) as a crown drench. Five hundred to 1 l of the fungicide solution was applied in between the leaf bases around the bud leaf to wet the bud thoroughly. Four treated palms died while others recovered after two rounds of application at a 2-weekly interval.

Another bud rot epidemic was reported from Eastern estate, Boyawalana. A total of 18 palms have succumbed due to the diseases. Ridomil (4g/l) and Mancozeb (2g/l) solutions were applied to 20 and 80 affected palms respectively. No newly affected palms were detected after the treatment.

b. An epidemic of leaf blight disease was reported from coconut nursery (CCB) in Walpita. The disease has affected DxT poly bagged seedlings. Mancozeb (Manzate) was applied to 14 seedlings as a spray (6g/l) and another 7 seedlings were sprayed with a 1% solution of copper (Coblite). All the treated palms were free from fresh lesions after the treatment application.

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Biological and chemical control

- a. Coconut caterpillar: All infestations were successfully controlled by release of parasitoids. The number of parasitoids released is given in the Table.
- b. Synthesis and sale of red weevil pheromone: Pheromone synthesis in the CRI laboratory continued and a total of 5955 vials were sold to the growers and CCB regional offices.
- c. Chemical control: Issue of monocrotophos by directly by CRI was restricted only to CRI estates and experimental blocks. A total of 66.9 l of monocrotophos was issued. The requirement of the growers was supplied to the Coconut Cultivation Board.

Table. *Release of parasitoids in different provinces for the management of coconut caterpillar*

Parasitoid	Western	North western	Southern	Eastern	Sabaragamuwa	Northern	Total
<i>Eriborus trochanteratus</i>	1800	35,500	2100	22,050	800	850	63,100
<i>Bracon hebetor</i>	0	69,500	16,000	63,500	0	7000	156,000
<i>Goniozus nephantidis</i>	1250	38,200	5250	46,000	0	0	90,700
<i>Brachymeria nephantidis</i>	1000	25,500	1500	25,500	0	0	53,500
Total	4050	168,700	24,850	157,050	800	7850	363,300

4. TRAINING AND EXTENSION ACTIVITIES

Extension activities

Divisional staff participated as resource personnel in various training programmes arranged by the CRI and other Institutions. Students from universities, technical colleges, schools and growers visited the Division during the year.

Acknowledgements

I am grateful to the staff of Crop Protection Division for their dedication and valuable contribution to the research programmes of the Division. Their cooperation and assistance in research and other activities during the year is greatly acknowledged. I am grateful too to the contract staff for their hard work. Sincere thanks are extended to the Head and staff of the Biometry Division for the assistance given in designing experiments and analysis of data. I thank Dr. N. Nanayakkara of Rinzen Laboratories for collaborating in research projects. I acknowledge the funds provided by the Coconut CESS, Council for Agricultural Research Policy, and Department for International Development, UK and Asian Pacific Coconut Community for conducting several research projects.

REPORT OF THE BIOMETRY DIVISION
Head - T S G Peiris, Ph. D; FRS

1. GENERAL

The Division assisted the research divisions in designing field, lab & glass house experiments, designing sampling methods and structured questionnaires for socio-economic and other types of surveys, analyzing data and interpretation of statistical results. Majority of designs recommended were randomized complete block designs with plot size varies from nine to six, but alternative experimental designs which are deviate from the standard classical designs were introduced due to lack of land and planting materials. A 5-day workshop on "Use of Statistics and Data Analysis" was conducted for the research staff at CRI.

The computer network system with 34 workstations was administrated efficiently and the institute website (www.cri.lk) was updated throughout the year. Assistance was given in installing software, upgrading computers and repairing computers, printers, UPSS and other related instruments. Training classes for different computer applications were conducted.

Four agro-meteorological stations and three rainfall stations were maintained. Climate data were given to various government organizations, private organizations and some growers on request. Daily data of all climatic variables at Bandirippuwa, Ratmalagara, Ambakelle and Maduro-Oya were submitted monthly to the Department of Meteorology, Colombo. Databases on climate, yield data of CRI estates and medical aid scheme were updated.

Diagnostic survey report titled, "Coconut Research, Development and Dissemination of Technologies - Growers Perception" was released and submitted to Ministry of Coconut Industries and other relevant organizations. Some of the recommendations highlighted in the report were implemented by CRI and Coconut Cultivation Board during the year.

Consumer survey on coconut and coconut oil in collaboration with the Department of Census and Statistics (DCS) and yield capture survey on coconut yield in collaboration with the Regional Managers and Coconut Development Officers of Coconut Cultivation Board were carried out during the year. Based on 7000 householders responded to the consumer survey the mean consumption rate per person for culinary purposes was 104 nuts and 7.2 bottles of during 2006. The yield capturing survey found that the national mean yield per bearing palms in 2006 was 58 nuts.

The observed national yield for the year 2006 was 2859 million nuts as against the estimated value of 2866 million nuts. The predicted national yield for the year 2007 was 2935 million nuts.

During the surveys, nearly 1000 coconut growers were met and advised on various problems in coconut cultivation. The Head of the Division participated two CRI-CCB dialogs held at Kalutara and Middeniya organized by the Technology Transfer Division.

2. ASSISTANCE IN COMPUTER RELATED WORK

1. The website of the CRI (www.cri.lk) was maintained and updated several times.
T S G Peiris
2. Climate database of the coconut growing areas and yield database of CRI estates were updated
K P Waidyarathna
3. Continuous assistance was provided to all divisions on the use of Internet system and Emails.
T S G Peiris, S S Rajapakse, J D J S Kularatna & W S Wickramarachchi
4. Co-ordinated the work in developing computer programs for analyzing databases related to personal management system and monthly transport system in the Establishment Division.
W S Wickramarachchi
5. Assistance was provided for hardware and software, and co-ordinate activities of computers in the Institute.
S S Rajapakse, W S Wickramarachchi & J D J S Kularatna
6. Computerization of all the weather variables recorded at seven meteorological stations continued throughout the year.
J D J S Kularatna, W B P Fernando & J H U Jayamaha
7. Assistance was provided for maintaining and processing activities of MAS.
J D J S Kularatna

3. STATISTICAL ASSISTANCE

1. A five day in-house workshop on 'Use of Statistics and Data Analysis' was conducted at the CRI for research officers.
T S G Peiris
2. Analyses of various long-term and short-term field experiments, lab experiments, and surveys were carried out. Undergraduates and postgraduates from the different universities were provided with statistical analysis in respect to their projects.
T S G Peiris, K P Waidyarathna, J D J S Kularatna, and W E R C Fernando
3. Two postgraduate theses on Applied Statistics at PGIA and one Postgraduate on Applied Statistics PGIS were supervised. Various papers in local and international journals were referred
T S G Peiris, G Peiris

4. RESEARCH PROJECTS

Thrust Area: CROP PRODUCTION/IMPROVEMENT/PROCESSING

Project 1: YIELD CAPTURING SURVEY

Objective: To identify yield variability between district and seasons as such information is not available for policy decision in the coconut industry.

Methodology:

Data capture survey was continued with the assistance from Coconut Development Officers (CDOO) of the Coconut Cultivation Board (CCB). Five estates were identified from each CDO range within all CCB regions excluding the Northern Province. In addition those selected estates data were acquired from selected estates in Puttlam, Gampaha and Kurunegala CCB regions by the division staff.

Results

This highest annual yield per bearing palm was observed in Marawila (75 nuts) followed in Ampara (73 nuts) as shown in Table 1. The lowest yield was observed in Matara (45 nuts/palm). The yield per bearing palm in the CCB regions of Galle, Kuliyaipitiya, Kurunegla, Mutable, Matara and Ratnapura were below the national average of 58 nuts per bearing palm. During the year highest yield per pick was observed during May/April and lowest yield per pick was during Jul/Aug. (Table 2). The pattern of bi-monthly yield varied from region to region. This could be mainly due different pattern of bi-monthly rainfall during 2005 in those regions.

The observed total national yield (Table 2) during 2006 was 2859 million nuts which was almost equal to the predicted value (2866 million nuts) in October 2005 (Figure. 2). Of the CCB regions the highest percentage of the national yield (15.5%) was from the Kurunegala region (442.5 million nuts). Nearly 55% of the national yield was contributed from the four CCB regions namely Kurunegala, Kuliyaipitiya, Marawila and Yamahas. At the end of each bi-monthly period the observed yield distribution by CCB regions was distributed to the relevant organizations and CCB regions.

Table 1. Observed bi-monthly yield in 2006 by regions (nuts/bearing palm)

CCB Region	Jan /Feb	Mar/ Apr	May /Jun	Jul /Aug	Sep /Oct	Nov /Dec	Total (nuts/p/y)
Ampara	10.7	12.9	11.2	12.5	13.4	12.8	73.6
Annuradapura	11.6	9.0	8.9	8.9	10.5	9.8	58.7
Galle	8.2	8.9	10.7	10.5	7.1	6.8	52.2
Gampaha	6.8	11.8	12.8	11.4	10.0	7.6	60.3
Hambantota	7.2	9.6	12.0	13.1	8.6	7.4	57.9
Kalutara	8.9	11.9	12.1	11.2	9.9	8.7	62.7
Kegalle	6.6	9.4	11.7	11.9	11.5	8.3	59.4

CCB Region	Jan /Feb	Mar/ Apr	May /Jun	Jul /Aug	Sep /Oct	Nov /Dec	Total (nuts/p/y)
Kuliyapitiya	8.3	10.4	9.9	7.6	8.6	8.6	53.4
Kurunegela	7.1	9.3	9.8	8.2	8.1	6.5	48.9
Marawila	13.0	14.4	13.5	11.2	11.4	11.7	75.1
Matale	6.8	7.0	8.7	6.8	9.8	7.5	46.7
Matara	4.9	8.8	9.5	8.0	7.7	5.9	44.9
Monaragala	12.8	7.2	8.0	11.4	10.3	12.0	61.7
Polonnaruwa	11.7	11.0	9.4	8.7	11.0	9.8	61.7
Ratnapura	7.6	8.7	10.1	11.1	12.0	6.8	56.3
Other areas	8.5	10.0	9.5	8.4	8.6	7.1	52.1
National	8.5	10.4	11.0	9.7	9.7	8.3	57.6

Table 2. Contribution to the national yield (million nuts) in 2006 by CCB regions

CCBR	Jan /Feb	Mar /Apr	May /Jun	Jul /Aug	Sep /Oct	Nov /Dec	Total
Ampara	6.5	9.8	7.2	5.1	8.4	8.7	45.8
Annuradapura	19.4	19.4	15.3	13.1	16.3	15.8	99.2
Galle	16.6	22.9	25.5	16.6	15.9	15.6	113.1
Gampaha	38.9	80.3	72.1	56.8	57.0	45.0	350.0
Hambantota	22.0	29.5	40.7	34.3	22.6	23.0	172.2
Kalutara	23.4	36.6	33.2	24.8	24.4	22.9	165.2
Kegalle	14.9	20.8	24.7	22.5	23.9	18.6	125.4
Kuliyapitiya	56.4	84.0	66.8	43.7	59.0	64.0	373.9
Kurunegela	63.6	97.2	88.1	61.5	71.7	60.4	442.5
Marawila	69.1	92.7	72.5	50.2	60.7	65.2	410.4
Matale	15.9	21.5	18.9	12.4	21.2	17.8	107.7
Matara	10.9	16.2	20.2	14.6	15.8	13.1	90.8
Monaragala	18.3	15.3	9.1	12.2	16.6	14.7	86.2
Polonnaruwa	10.0	10.2	8.4	6.1	9.8	9.3	53.8
Ratnapura	14.6	20.4	17.9	17.9	21.8	15.9	108.5
Other areas	17.8	25.9	18.8	15.5	19.1	17.3	114.4
National	425	603	539	407	464	427	2859

The comparison between observed and predicted bi-monthly national yield distribution for 2006 is shown in Figure. 1. The percentage error varies from 10.6% during Jul/Aug to 11.5% during Jan/Feb resulting the percentage error for the annual yield was 0.04%.

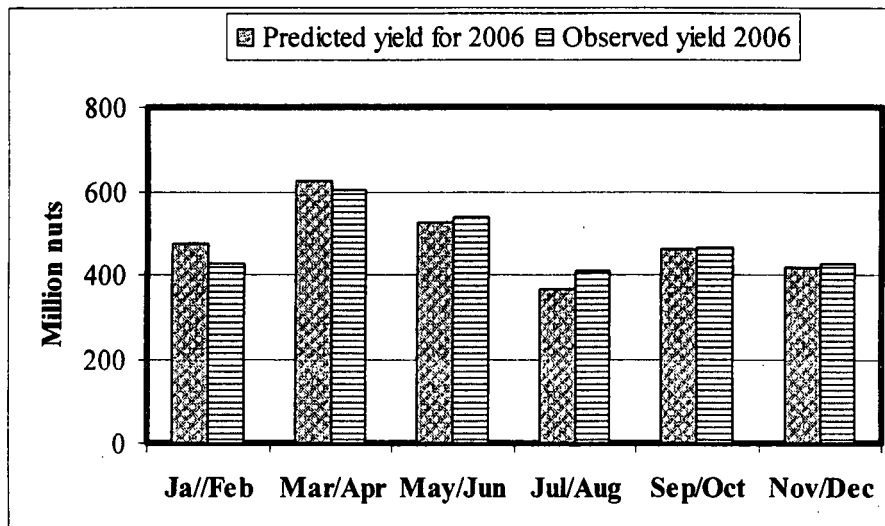


Figure 1. Comparison between predicted and observed bi-monthly national coconut production in 2006

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J D J S Kularatna and W K M K Herath*

Thrust Area: CROP PRODUCTION/IMPROVEMENT/PROCESSING

Project 2: PREDICTION OF ANNUAL NATIONAL COCONUT PRODUCTION FOR 2007

Objective: Prediction of annual and bi-monthly national yield for 2007

Results:

Using the integrated crop forecasting model (CRI Annual Report, 2005) which incorporates climate effect and technology effect, the national coconut production for 2007 was predicted as 2935 million nuts in October 2006. Prediction of national coconut production for 2007 by two monthly seasonal bases (Jan/Feb - Nov/Dec) was also done using a composite index based on bi-monthly national yield distribution in 2005 and 2006 and bi-monthly distribution rainfall intensity in 2005 and 2006 in the main agro-ecological regions in coconut growing areas. (Figure.2)

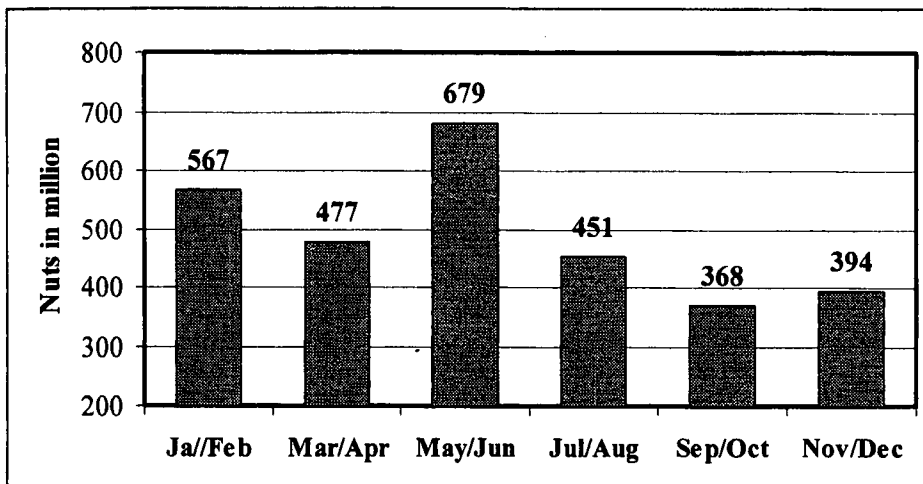


Figure 2. *Predicted pattern of bi-monthly national yield for 2007*

T S G Peiris

Thrust Area: CROP PRODUCTION/IMPROVEMENT/PROCESSING

Project 3: IDENTIFICATION OF CONSUMPTION PATTERN OF COCONUT NUTS AND COCONUT OIL

Objective:

To identify pattern of consumption rate of coconut nuts and oil by district, as such information would be useful to control imports of substitute oils, compute cost of living indices by districts and identify the actual nut consumption locally.

Methodology:

From April 2006, the consumer survey on the coconut nut and coconut oil was conducted with the assistance from the Department of Census & Statistics. Due to prevailing conditions in the country the survey was not covered the districts in North and Eastern provinces. The amount of coconut oil and fresh nuts consumed by a family was monitored for five weeks from the ten families selected within census block by the statistical officers in DCS who conducted monthly labour force survey. Data were posted to Biometry Division by the householders. In certain cases divisional staff went to each householder to collect from the selected house holders.

Results

Table 3. Consumption rate of coconut nut and coconut oil in 2006

District	Consumption rate/person/year	
	Number of nuts	Number of oil bottles
Anuradhapura	111.6	7.3
Badulla	62.1	8.2
Colombo	90.0	6.9
Galle	104.4	6.8
Gampaha	81.9	6.6
Hambantota	126.9	6.7
Kalutara	101.7	7.7
Kandy	98.1	7.1
Kegalle	131.4	6.1
Kurunegala	151.2	6.5
Matale	101.7	8.1
Matara	106.2	6.7
Monaragala	101.7	8.6
Nuwara Eliya	64.8	7.5
Polonnaruwa	103.5	5.7
Puttlam	124.2	8.5
Ratnapura	120.6	7.6
Mean \pm SE of	104.8 \pm 3.5	7.2 \pm 0.2
CV (%)	21.6	11.5

(SE – standard error)

Mean rate of nut consumption in 2006 has increased to 105 nuts compared with corresponding value 95 nuts in 2005 (CRI Annual Report, 2005). The total number of nuts utilized for fresh nut consumption alone in 2006 is 2038 million nuts. The rate of oil consumption has reduced from 7.7 bottles to 7.2. The study found that there is no significant correlation between consumption rate of coconut nut and oil. The variability of nut consumption between districts (CV=21.6%) is almost double that of oil consumption. The consumption rate of fresh nut was exceptionally high in Kurunegala district while it was exceptionally low in the districts of Badulla and Nuwara Eliya. The oil consumption rates in Badulla and Nuwara Eliya were higher than the national average.

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Thrust Area: CROP PRODUCTION/IMPROVEMENT/PROCESSING

Project 4: EFFECT OF MONTHLY PICKING AT FARM LEVEL.

Objective: To find the impact of monthly picking (1M) vs bi-monthly picking (2M) at farmer's land

Methodology:**Treatments:** Monthly picking vs Bi-monthly picking**Experiment Design:** Randomized block design with single palm plot (Number of blocks varied from location to location)**Locations:** Three locations from each of four land suitability class (LSC) of coconut: (S₁ - S₄) were selected.**Results:****Table 4.** *Observed yield/palm during the period from January to October 2006*

LSC of Coconut	Location	Harvesting frequency		Significance	% increase in 1M with respect to 2M
		1M	2M		
S1	Marawila	135.9	134.3	ns	1.2
	Pambala	114.3	75.1	**	52.2
	Sirigampola	93.9	75.3	**	24.7
	Mean	114.7	95.0	**	20.7
S2	Nattandiya	95	71	**	33.8
	Kuliyapitiya	78.7	56.1	**	40.3
	Madurankuliya	115.9	93.3	**	24.2
	Mean	96.5	73.5	**	31.4
S3	Mangalaeliya	78.6	76.9	ns	2.2
	Kobeigane	53.9	35.5	**	51.8
	Dunkannawa	119.6	84.6	**	41.4
	Mean	84.0	65.7	**	28.0
S4	Sembukattiya	94.2	65.3	**	44.3
	Dunkannawa	106.1	101.4	ns	04.6
	Bingiriya	86.9	61.4	**	41.5
	Mean	95.7	76.0	**	25.9

** Significant at 1% level , ns – not significant

The annual yield per palm obtained using 1M picking was significantly higher than that obtained using 2M picking in all farmers field (Table 4). The percentage increase varied from location to location. Of the four land suitability classes for coconut (S₁ – S₄) the highest percentage increase was observed in S₂ and all three estates in S₂ showed high percentage increase. The rates of increase were low during 2006 compared with the corresponding values in 2005 CRI (VRI Annual Report, 2005).

When the selling price of a nut varied from 10 – 15/= and picking cost per palm varied from 18-22/=Rs, the profit from a coconut palm per year in S₁, S₂, S₃ and S₄ lands varied (25-200)/=, (50-240)/=, (40-170)/= and (25-200)/= respectively. The cost for nut collecting was ignored as it is reasonable to assume that the collecting cost is negligible in small holdings.

The results confirmed that the monthly picking is more beneficial with respect to nut increase and income gain at the farmers' lands irrespective of land suitability class and the

highest beneficial effect were from S₂ lands. Similar results were observed in 2005. Comparison of copra content was not done in this study as the number of nuts received in a pick in a given estate is not sufficient to use for copra machine.

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TRUST AREA: CROP PROTECTION

PROJECT: 5: TEMPORAL VARIABILITY OF MITE INFESTATION

Objective: To identify the intensity of mite damage over time

Methodology:

A survey was carried out during the year in the three selected coconut mite infested zones (MIZ) namely Anuradhpaura, Puttalam and Kurunegala. The sampling method was two-stage stratified random sampling. The five mite infested estates were selected from each MIZ. The nuts were harvested at bi-monthly interval from the randomly selected ten mite infested palms in each estate. Harvested nuts were grouped into two categories based on (a) status of mite damage (Nuts having no mite scares – MF, and nuts having mite scares - MI), and (b) nut size (full priced nuts – S1 and half priced nuts – S2, barren & deformed - BD). The full price nuts were defined as the nuts which could be sold at the full price and half price nuts were referred as nuts which are generally sold at half of a full price nut. This was determined in consultation with the owner of the estate or the buyer of nuts. Nuts do not belong to full or half priced nuts were named as either barren or deformed. Those nuts can not be sold irrespective of MI or MF. Barren nuts are those of with no water inside the nut. Deformed nuts are those which do not belong to either normal shape or barren.

Results:

Table 5. Distribution of nuts under each category by MIZ x Period

MIZ	Period	Mite free			Mite infested		
		Full Sized (MF S1)	Half Sized (MF S2)	B & D (MF BD)	Full Sized (MI S1)	Half Sized (MI S2)	B & D (MI BD)
A	April	0.49	0.00	0.00	64.11	28.83	6.57
A	June	0.80	0.00	0.00	54.12	21.41	23.67
A	August	3.46	0.00	0.00	53.35	34.77	8.42
A	October	5.45	1.05	0.21	51.99	33.96	7.34
A	December	6.17	0.13	0.13	66.71	24.56	2.28
K	April	5.23	0.37	0.00	63.74	22.62	8.04
K	June	2.03	0.24	0.00	55.08	38.59	4.06
K	August	16.16	0.00	0.00	54.56	27.76	1.52
K	October	18.37	0.00	0.00	62.36	19.27	0.00
K	December	34.82	0.32	0.00	47.28	17.57	0.00
P	April	7.69	0.00	0.00	74.29	15.05	2.97
P	June	10.33	0.45	0.27	68.39	13.80	6.77
P	August	7.69	0.00	0.00	78.61	10.88	2.81
P	October	28.30	0.00	0.00	62.68	7.13	1.89
P	December	46.05	0.00	0.00	52.41	1.10	0.44

Anuradhapura, K – Kurunegela & P – Puttalam

The table 5 clearly indicates that percentage of barren and deformed nuts are higher among mite infested nuts and they are almost negligible among mite free nuts.

Table 6. Percentage of mite infested nuts (MI_S1+MI_S2+MI_DB) in mite infested palms by MIZ

MIZ	% mite infested nuts
A	96.4
K	84.5
P	79.9

LSD at 5% level = 11.7

Results in Table 6 found that percentage of mite infested nuts during the period from April to December in Anuradhapura (96.4%) was significantly higher ($p < 0.005$) than that in Kurunegela (84.5%) or Puttalam (79.9%), but no significant difference between Kurunegela and Puttalam. However, mite infested full priced nuts were significantly higher (67%) in Puttalam than that in Anuradhapura or Kurunegela and mite infested half priced nuts were significantly lower (9%) in Puttalam than that in other two places.

Table 7. *Percentage of mite infested nuts (MI_S1+MI_S2+MI_DB) in mite infested Palms by months*

MIZ	% mite infested nuts
April	95.4
June	95.2
August	90.9
October	82.2
December	70.7

LSD at 5% level = 15.1

Results in Table 7 indicates that % mite infested nuts in a mite infested palm is significantly lower ($p < 0.005$) during December than that during other months irrespective of the location. This could be due to the fact that in general there was unusually high rainfall distribution during October and November in most parts of the country. The percentages drop of mite infested nuts during December in Puttlam and Kurunegala were much higher than that in Anuradhapura.

Temporal variability of the percentage of mite infested full priced and half priced nuts are shown in Figures 3 and 4 respectively. Analysis found that there was not significant correlation ($p > 0.005$) between mite infested half priced nuts and full priced nuts.

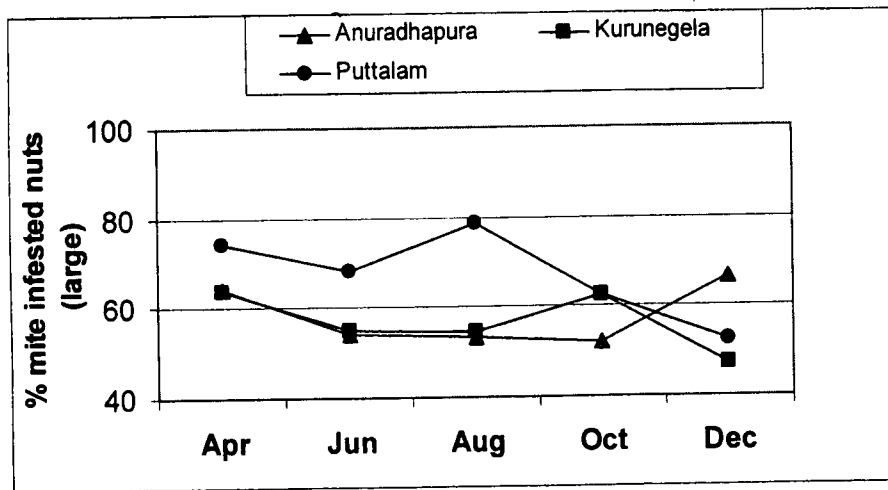


Figure 3. *The temporal variability of mite infested full priced nuts*

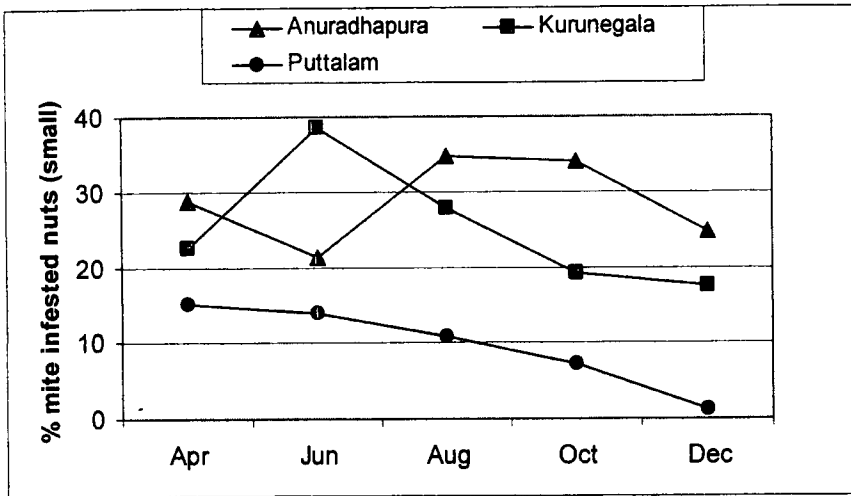


Figure 4. *The temporal variability of mite infested half priced nuts*

From the results in Table 5 it can be confirmed that the percentage nut loss per mite infested palm per year varied from 5.5% during October in Puttalm to 34.4% during June in Anuradhapura with a mean of 15.7% irrespective of the location time. This means that the mean loss to the grower due to a mite infested palm is 15.7% from his income to be received if there was no mite at all.

T S G Peiris, K P Waidyaratne, & J D J S Kularatne

TRUST AREA: CROP PRODUCTION/IMPROVEMENT/PROCESSING

PROJECT: 6: ADAPTATION TO CLIMATE CHANGE IN COCONUT GROWING AREAS

Objective: To study effect of global climate change on coconut cultivation

Results:

Despite the differences in physical and socio economic characteristics among different countries, global climate change has become a problem to agriculture and in particularly for coconut industry in Sri Lanka. The observed global average temperature from 1950 to 2005 shown in Figure 5 confirms the gravity of global climate change on agriculture. If this observed trend is continued it is expected that the global mean temperature may be increased from 1.50C to 5.80C in 2100, and increase of CO₂ from 280 ppm to 350 ppm (25%), N₂O from 270 ppb to 316 ppb (17%), CH₄ from 700 ppb to 1760 pp (150%), sea level from (10 – 20) cm/y and drought and floods from (20-40)%.

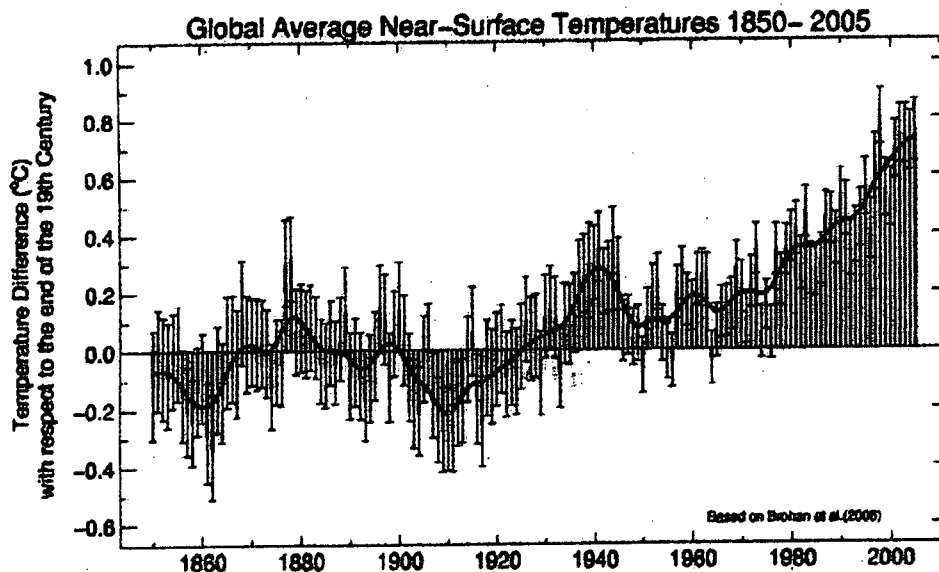


Figure 5. Temporal variability of the global mean surface temperature

The studies carried out in coconut growing areas confirmed that changes in monsoon rainfall pattern and increase in maximum air temperature are two key factors on the variability of coconut production in Sri Lanka. Further, it was found that. The increase in minimum and mean air temperature, higher warming rate for maximum temperature than minimum or mean air temperature, increase in soil temperatures at different depth, change in onset and withdrawal of rainy spells, reduction in rainfall intensity and high variability of rainfall in the principal coconut growing areas.

Cutting coconut trees, urbanization of coconut growing areas and improper land utilization are the local influences to such changes in coconut growing areas, in addition to the normal influence of global warming due to green house gasses,. The possible impacts on coconut cultivation due to the observed climate change are:

- reduction in natural pollination
- drop in female flowers
- face to water stress
- increase pest & diseases
- reduction in soil fertility
- difficulty in planning cultural practices
- scarcity of water for irrigation
- no rain when requires
- more rain during unwanted period
- reduce the efficiency of fertilizer application
- increase mortality rate of seedlings
- drop in yield

Therefore the adaptation techniques such as rainwater harvesting, establishment of cover crops, use of organic fertilizers, growing of shade trees, plan according to location

specific cropping calendars etc, are recommended to deal with vulnerabilities associated with climate change.

T S G Peiris

Trust Area: CROP PRODUCTION/IMPROVEMENT/PROCESSING

Project 7: FUTURE OUTLOOK OF THE COCONUT INDUSTRY

Objective: To project the status of coconut production by 2050

The population in Sri Lanka was projected up to 2050 by developing an exponential function and assuming the rate of increase is slower after 2025 (Figure 6). The projected population for 2010 and 2050 was 20.93 and 24.59 million respectively.

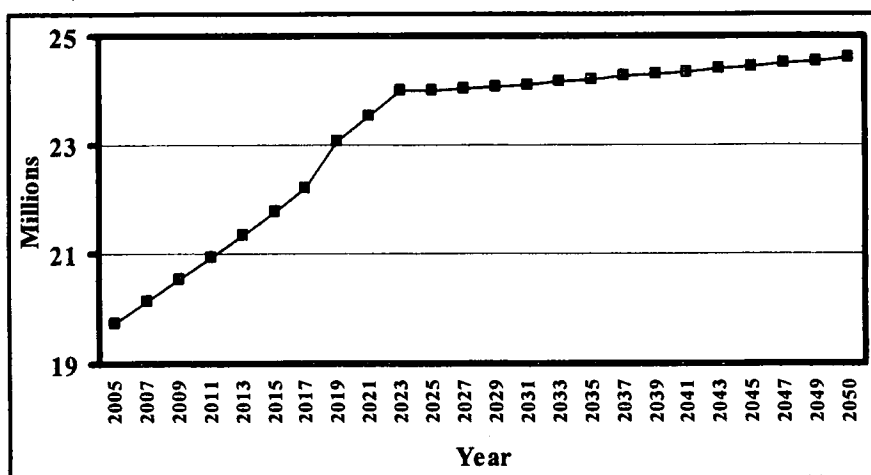


Figure 6. Project population in Sri Lanka

Based on the population projection nut requirement for local use was computed under two extreme scenarios (Table 8). The two extreme scenarios (Table 8) was taken based on past and present consumer survey findings and amount of import substitute oil for coconut oil in past.

Table 8. Nut requirement (million nuts) for local consumption – medium term projections

Year	Scenario I	Scenario II
	99 nuts and 3 bottles of coconut oil	97 nuts and 2 bottles of coconut oil
2010	2270	2431
2020	2552	2733
2030	2614	2828
2040	2640	2848
2050	2667	2857

Using integrated model developed to forecast annual national coconut production (ANCP) and projected 3 monthly seasonal rainfall by HadCM3 General Circular Model ANCP was projected for 2010, 2020, 2030, 2040 and 2050 (Figure 7).

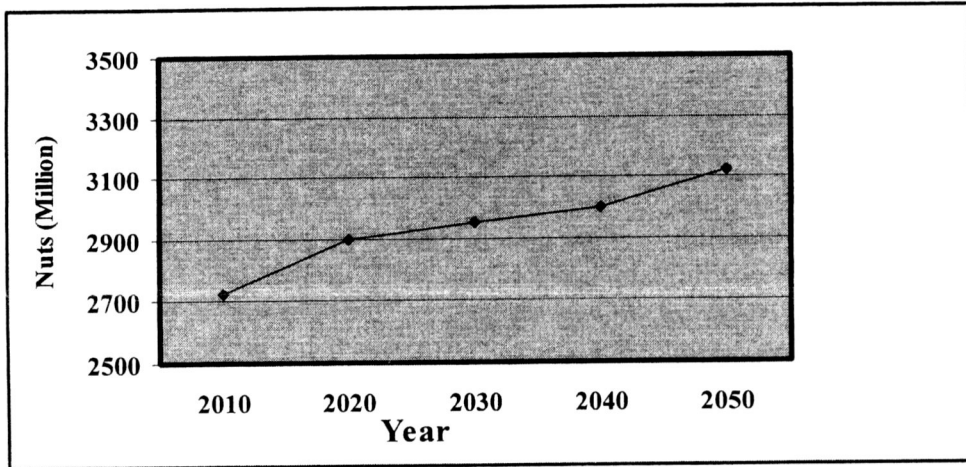


Figure 7. *Projected ANCP at 2010, 2020, 2030, 2040 and 2050 based on HadCM3 GCM*

Though modeling suggests that expected climate change tends to increase national coconut yield due to fertilization effect of CO₂ if the national coconut extent and technologies are slowly increases, the project yield after 2020 would be mainly sufficient for local consumption only. Thus in order to cater for other stakeholders it is necessary to accelerate the new/re planting program of coconut with high yielding varieties.

T S G Peiris

5. MISCELLANEOUS STUDIES

5.1 Guide to irrigation

Irrigation of coconut palms has been recommended around 2m radius circle leaving 0.3m radius circle ('effective root zone for irrigation') when rainfall is insufficient to compensate for water loss by evapotranspiration. The evapotranspiration is the amount of water transpired from the surface of the crop which depends on pan evaporation and crop factor. The efficiency of irrigation can be obtained when the correct amount was applied at the correct period.

The water requirement for coconut is mainly decided by storage capacity and availability of soil water as amount of runoff, pan evaporation, capillary rise, and deep percolation in the soil and amount of rainfall received. Ignoring soil properties, the amount of water that could be remaining in the effective root zone of the palms due to different amount of rainfall was computed irrespective of the soil properties (column 2 of Table 9). Accordingly, the amount of water required for irrigate in a rainy day and the number of days that irrigation could be postponed is given rainy day is shown in Table 9, for three different rates of irrigation namely 40 l, 50 l and 60 l. per day. These results would be useful to grower to monitor irrigation.

According to Table 9, if the rainfall is 0.5mm/day, 34 l can be applied by irrigation instead of 40 l. If the rainfall is 2.5mm/day, only 9 l can be applied by irrigation instead of 40 l. If the rainfall is 3.5-4.5 mm/day, irrigation is not required for soils recommended 40 l/day. If the rainfall is 5.0 mm/day, irrigation can be delayed by one day. If the rainfall is 20.0 mm/day, irrigation can be delayed by five days. Similar results can be obtained from Table 9 for soil where recommended amount is 50 l/day/palm and 60 l/day/palm.

In order to obtain more beneficial effects from the above results, it is recommended to use a rain gauge.

Table 9. Amount of water required to be irrigated vs. amount of rainfall

Amount of rainfall (mm)	Equivalent amount of water	Amount required to irrigate and days to be postponed the irrigation, if the recommended amount is		
		40 l	50 l	60 l
0.5	6	34	44	54
1.0	12	28	38	48
1.5	18	22	32	42
2.0	25	15	25	35
2.5	31	9	19	29
3.0	37	3	13	23
3.5	43	0	7	17
4.0	49	0	1	11
4.5	55	0	0	5
5.0	61	(1)	0	0
10.0	123	(2)	(1)	(1)
20.0	246	(5)	(4)	(3)
30.0	369	(8)	(6)	(5)

Parenthesis indicated the number of days where irrigation can be delayed

T S G Peiris and K P Waidyaratana

6. CLIMATE IN CRI RESEARCH CENTERS

The four meteorological stations at Bandirippuwa Main Research Centre, Ratmalagara Research Centre, Ambakelle Genetic Resource Center and Maduru Oya Genetic Resource Center were maintained. Daily recordings were taken throughout the year on rainfall (mm), air temperature maximum and minimum ($^{\circ}$ C), evaporation (mm), relative humidity morning and afternoon (%), sunshine duration (hrs/d) and soil temperature (morning and afternoon) at 5, 10, 20, 30, 60 and 120 cm depth. The rainfall, evaporation and sunshine duration were measured using rain gauge, class A evaporation tank and Campbell stokes sunshine recorder respectively. The maximum and minimum air temperatures were recorded in Stevenson Screen using mercury and alcohol-in-glass thermometers respectively. Relative humidity was obtained by transforming the current dry and wet bulb temperature recorded using ventilated mercury-in-glass psychrometer. Data were recorded at 8.30 hrs and 15.30 hrs daily.

6.1 Climate at Bandirippuwa Main Research Center (Table 10)

Rainfall:

The total rainfall for the year was 2180 mm. This rainfall is 29% higher than the last year rainfall (1682.9) and 27% higher than long-term (1995-2005) annual mean. The rainfall from January to September showed similar distribution as for ten year average, but rainfall from October to December was exception higher than long term mean 275%. The percentage contribution for three monthly seasons namely Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec were 11.7, 16.3, 13.6 and 58.4.

Temperature:

The monthly maximum temperature ranged from 30.7°C during September to 33.1°C during February and March. The monthly minimum temperature ranged from 21.0°C during January to 24.4°C during June. During this year mean monthly maximum temperature has increased by 0.3°C and mean monthly minimum temperature has decreased by 0.6°C with respect to 2005.

Sunshine:

Sunshine hours ranged from 3.9 hrs/day (November) to 8.5 hrs/day (February) with a mean 6.6 hrs/day. The year showed reduced sunshine hours compared to long-term average of 7.2 hrs/day.

Evaporation:

The lowest and highest evaporation was recorded in October and April with values 2.6 mm. and 4.6 mm. respectively. The average for the year was 3.7mm which is almost same as last year as well as long-term mean.

Relative Humidity:

The average relative humidity in the morning fluctuated between 80% during April to 86% during November/December. In the afternoon it varied around 73% during April to 82% during June.

6.2 Climate at Ratmalagara Research Center (Table 11)

Rainfall:

Total rainfall during 2006 (1837.1) has increased by 8.5% compared to the last 10 year mean (1996-2005). Rainfall during last quarter in 2006 has increased by 37% compared to long-term average of the first quarter, but rainfall during second quarter has dropped by 29% compared to long-term mean during second quarter. The contribution from three monthly seasons to the total was 11.2%, 17.4%, 9.9% and 61.5% respectively.

Temperature:

The monthly maximum temperature ranged from 30.7°C during July to 33.8°C during April. The monthly minimum temperature increased from January to June and then decreased from June to December.

Sunshine:

Sunshine hours ranged from 4.3 hrs/day (December) to 7.6 hrs/day (August) with a mean 6.3 hrs/day. The mean daily sunshine duration was higher compared to long-term mean of 5.6 hrs/day.

Evaporation:

The lowest and highest evaporation was recorded in November and August with values 2.0 mm and 3.8 mm, respectively with a monthly mean of 3.0 mm.

Relative Humidity:

The average relative humidity in the morning was 86% and that in the afternoon was 69%. Relative humidity in the after noon varied from 81% (August) to 90% (March). The corresponding values for relative humidity in the morning was 59% (February) to 74% (July).

6.3 Climate at Ambakelle Genetic Research Center (Table 12)**Rainfall:**

The rainfall during October (62.5 mm.) is exceptionally higher compared with the corresponding value in 2005. Monthly rainfall in 2006 has well distributed in all months except July. Contributions during Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec to the annual rainfall were 16.6%, 18.07%, 6.5% and 58.9% respectively.

Temperature:

Mean monthly maximum temperature was 31.7°C and it varied from 29.8°C during January to 33.1°C during April. Lowest minimum temperature was recorded during February and minimum temperature increased from February to June and then decreased up to December.

Evaporation:

Monthly evaporation was low during the year and mean daily evaporation was 3.1 mm. The highest evaporation was recorded during September (3.9 mm) and lowest was in December (2.2 mm).

Relative Humidity:

The average relative humidity in the morning was 82% and it is lower than the long-term average. The relative humidity in the afternoon was 70% and it is also below the long-term average. The morning and afternoon relative humidity was highest during March and October. Relative humidity afternoon and relative humidity (morning) was lowest during February and August respectively.

6.4 Climate at Maduru Oya Seed Garden (Table 13)**Rainfall:**

Unlike other locations monthly the rainfall distribution in 2006 is totally different from the distribution of the long-term means. Rainfall in January, March and October in 2006 has increased by 66%, 422% and 141% with respect to the corresponding long-term monthly average.

Total rainfall during the year was 1939.2 mm. and it is about 50% higher the compared the annual rainfall in 2005. It is 24% higher than the long term average. The contributions by three monthly seasons to the total were 32.0%, 8.6%, 7.2% and 52.2% respectively.

Temperature:

As for 2005 maximum temperature was lowest during January (29.6⁰C) and it showed increasing trend from January to June (35.7⁰C) and then decreased up to December. Minimum temperature varied from 21.8⁰C during January to 24.5⁰C during March.

Sunshine:

Mean sunshine duration during the year was 5.2 hrs/day and it varied from 4.3 hrs/day (in December) to 6.2 hrs/day (in August).

6.5 Rainfall at Poththukulama, Walpita and Pallama Research Centers (Table 14)

The monthly rainfall distribution for the year 2005 along with long-term averages (based on data availability) for the above three stations are shown in Tables 13. The total rainfall during the year in all three stations is higher than the long-term average. Rainfall in May and August in 2006 at all three stations was lower than the corresponding long-term means.

The monthly rainfall distribution in 2006 in PRS is almost similar to the distribution of long-term monthly distribution, but rainfall during October and November in 2006 was significantly higher than the corresponding long-term means. Similar trend was found in Walpita as well with exceptional during November. In Pallama rainfall during March, July, October, November and December in 2006 was significantly higher than the corresponding long-term means.

Bi-monthly rainfall distribution during 2006 of the four agro-meteorology stations and three rainfall stations are shown in Figures 8 and 9 respectively.

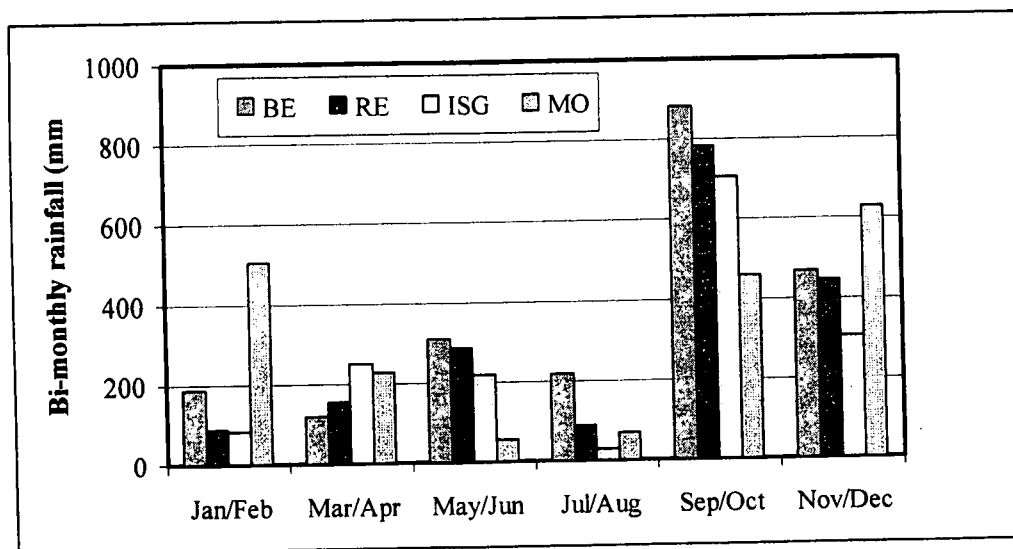


Figure 8. Bi-monthly rainfall distribution in 2006 in BE, RE, ISG and MO

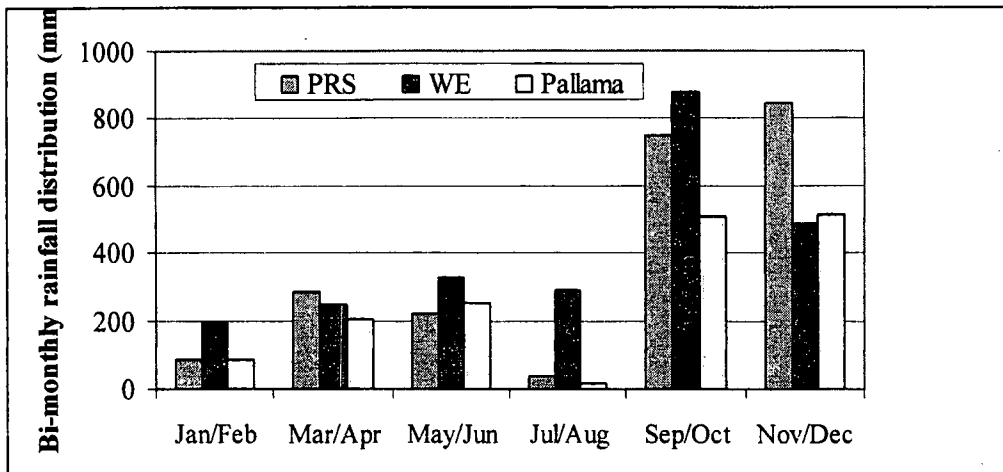


Figure 9. Bi-monthly rainfall distribution in 2006 in PRS, WE, and Pallama

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Table 10. Monthly climate variables in Bandirippuwa (BE) Main Research Centre in 2006 and 10-year average

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2006	167.0	20.3	67.9	49.0	174.2	133.3	43.2	174.7	78.0	802.2	445.5	24.9	2180.2
	1996-2005	59.0	48.0	78.9	209.4	180.6	124.9	78.1	77.2	145.3	366.3	256.9	90.1	1714.7
Tmax (°C)	2006	30.9	33.0	33.1	32.9	32.7	31.8	30.8	31.4	30.7	31.6	31.8	31.9	31.9
	1996-2005	31.4	32.8	32.9	32.3	31.7	30.9	30.5	30.6	30.7	30.4	30.8	31.1	31.3
Tmin (°C)	2006	21.0	21.5	21.7	23.4	24.3	24.4	23.3	23.0	22.7	23.2	22.9	22.6	22.8
	1996-2005	21.6	21.7	22.3	23.7	24.4	23.9	24.2	24.0	23.8	22.8	22.4	21.8	23.0
Sunshine (hrs)	2006	7.0	8.5	8.0	6.2	6.6	7.9	6.6	7.3	6.7	6.2	3.9	4.8	6.6
	1996-2005	7.5	8.5	8.3	7.4	7.0	6.7	6.8	7.4	7.5	6.5	5.6	7.1	7.2
Evap. (mm)	2006	3.5	4.4	4.0	4.6	3.6	3.6	4.2	3.9	3.2	2.6	3.1	4.3	3.7
	1996-2005	4.2	4.4	4.5	4.3	3.8	3.7	3.9	3.9	3.8	3.2	3.2	3.7	3.9
RH _{am} (%)	2006	82	83	83	80	82	86	83	86	85	85	86	86	84
	1996-2005	83	82	80	82	83	84	84	83	82	85	85	83	83
RH _{pm} (%)	2006	78	80	78	73	78	82	80	78	78	79	81	77	78
	1996-2005	69	68	69	74	79	80	78	77	77	78	79	73	75

Table 11. Monthly climate variables in Ratmalagara (RE) Research Centre in 2006 and 10-year average

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2006	82.9	3.0	118.8	34.1	160.6	125.1	17.7	69.0	95.3	686.3	371.2	73.1	1837.1
	1996-2005	55.7	49.8	78.0	180.7	170.5	101.2	53.8	48.3	130.2	361.9	351.5	111.6	1693.2
Tmax (°C)	2006	31.3	33.7	33.1	33.8	32.8	31.4	30.7	31.7	31.6	31.4	32.0	31.5	32.1
	1996-2005	31.7	33.3	34.2	33.0	32.0	31.1	30.9	31.4	31.7	30.9	31.2	30.9	31.8
Tmin (°C)	2006	21.7	22.6	23.2	24.6	25.1	25.1	25.2	24.3	24.5	23.4	23.2	22.4	23.8
	1996-2005	21.5	22.1	23.2	24.1	25.2	25.0	24.8	24.7	24.2	23.7	23.0	21.9	23.6
Sunshine (hrs)	2006	5.8	7.3	6.7	7.2	6.3	6.6	5.7	7.6	6.1	6.0	5.6	4.3	6.3
	1996-2005	5.0	6.4	6.7	6.3	5.7	5.3	5.2	5.9	5.7	5.2	5.1	5.3	5.6
Evap.(mm)	2006	2.4	3.7	3.0	3.5	3.3	3.2	3.6	3.8	2.9	2.2	2.0	2.3	3.0
	1996-2005	3.0	3.5	3.8	3.9	3.5	3.3	3.0	3.0	3.1	2.9	2.5	2.7	3.2
RHam (%)	2006	91	89	90	86	83	82	82	81	82	86	88	88	86
	1996-2005	87	86	86	85	84	83	81	81	81	86	88	88	85
RHpm (%)	2006	67	59	67	65	70	74	74	70	70	72	69	71	69
	1996-2005	67	62	65	71	76	77	75	72	72	77	78	73	72

Table 12. Monthly climate variables in Ambakelle (ISG) Genetic Resource Centre in 2006 and 10-year average

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2006	47.5	32.4	183.2	64.6	147.5	72.0	5.2	20.3	78.1	624.8	271.3	35.3	1582.2
	1996-2005	54.6	59.9	63.2	170.2	146.9	75.7	50.8	32.0	120.4	293.8	251.4	128.3	1447.2
Tmax (°C)	2006	29.8	32.1	32.4	33.1	32.8	31.5	31.1	32.3	31.9	31.2	31.6	30.3	31.7
	1996-2005	31.5	32.9	33.7	33.3	32.7	31.4	31.3	31.7	31.9	31.1	31.0	31.8	32.0
Tmin (°C)	2006	21.6	22.5	23.1	23.7	24.7	24.6	25.1	24.4	24.6	23.8	23.9	22.6	23.7
	1996-2005	21.7	21.8	22.9	24.0	25.0	25.2	24.9	24.9	24.4	23.7	23.1	22.5	23.7
Evap. (mm)	2006	2.6	3.8	3.4	0.0	3.2	3.4	3.3	4.0	3.1	2.7	2.3	2.4	3.1
	1996-2005	3.0	3.6	3.9	3.5	3.3	3.3	3.5	3.9	3.5	3.7	4.6	3.4	3.6
RH _{am} (%)	2006	81	84	88	80	80	80	81	78	82	86	85	84	82
	1996-2005	87	85	82	83	84	84	83	80	80	85	86	86	84
RH _{pm} (%)	2006	73	62	68	70	68	72	73	63	72	77	72	72	70
	1996-2005	69	66	67	74	77	77	81	76	71	72	78	79	74

Table 13. *Monthly climate variables in Maduru Oya (MO) Genetic Resource Centre in 2006 and 10-year average*

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2006	388.9	115.1	117.5	111.2	52.7	3.1	28.6	38.2	72.7	384.4	371.5	255.3	1939.2
	1996-2005	235.1	137.4	22.5	118.4	54.0	22.1	41.3	60.6	72.3	159.3	336.0	302.6	1561.6
Tmax (°C)	2006	29.6	31.1	33.7	35.0	35.2	35.7	34.9	34.9	34.8	33.6	31.4	29.8	33.3
	1996-2005	30.3	31.6	34.1	34.8	35.2	35.0	34.9	35.2	35.5	33.7	31.5	30.6	33.5
Tmin (°C)	2006	21.8	22.4	23.1	23.7	24.5	24.3	24.2	23.4	23.7	23.1	23.7	23.0	23.4
	1996-2005	20.7	20.3	20.4	22.0	22.3	22.7	23.1	22.6	22.3	22.0	22.3	21.7	21.9
SS (hrs)	2006	4.7	4.7	5.5	5.3	5.0	6.1	4.8	6.2	5.8	5.4	5.3	4.3	5.2
	1996-2005	5.6	6.4	8.5	7.2	7.5	7.1	7.8	7.9	7.3	6.3	5.2	4.6	6.8
Evap. (mm)	2006	3.5	3.6	4.1	4.3	4.4	4.8	5.5	5.5	5.6	5.0	5.0	4.0	4.6
	1996-2005	3.1	3.4	4.1	3.7	4.7	5.2	5.5	5.4	5.2	4.9	3.3	3.8	4.3
RH _{am} (%)	2006	89	87	83	76	73	71	66	70	73	78	88	90	79
	1996-2005	76	72	64	62	63	60	58	60	58	66	75	75	66
RH _{pm} (%)	2006	77	70	62	61	61	55	57	52	56	64	78	79	64
	1996-2005	88	87	84	71	73	70	68	66	68	75	84	87	77

Table 14. Monthly rainfall of the research centers at Poththukulama (PRS), Walpita and Pallama in 2006 and ten year average

Location	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PRS	2006	78.8	6.2	214.6	68.2	128.0	93.7	5.2	33.4	76.0	672.0	319.3	52.4	1747.8
	1996-2005	37.5	44.9	81.3	186.7	104.8	68.3	44.6	35.6	98.6	256.8	246.5	114.2	1319.8
Walpita	2006	132.5	61.4	220.4	25.5	130.7	197.3	30.9	259.0	51.5	823.4	447.4	41.9	2421.9
	1998-2005	88.9	74.9	103.0	292.3	235.4	178.5	121.2	120.1	229.9	401.7	321.5	91.5	2258.9
Pallama	2006	72.3	13.8	148.0	55.4	158.9	94.1	0.0	16.5	79.1	728.2	456.5	55.8	1878.6
	2001-2005	41.9	32.0	79.6	280.9	124.6	85.0	60.2	13.3	64.9	248.9	258.0	107.4	1396.7

REPORT OF THE TISSUE CULTURE DIVISION

Head - L K Weerakoon, Ph D

1. GENERAL

Field planting of 93 exotic coconut plants, raised from embryos collected from PNG and Ivory Coast, was accomplished during the year.

Forty embryo-cultured Dikiri palms were field planted at Middeniya Research Center as the first step in establishing demonstration plots of Dikiri palms in the mini-coconut triangle.

Twenty two tissue-cultured coconut palms were field planted at Bandirippuwa Estate. The growth of the tissue-cultured plants established previously at Bandirippuwa Estate, Lenawa Estate, Daisy Valley Estate and Pallama Seed Garden was found to be satisfactory. No abnormalities in vegetative growth or nut characters were observed in these palms.

Callus induction in plumules of several genotypes of coconut (Sri Lanka Tall, DY X T hybrid, Dwarf yellow and clonal plants of DG X T hybrid) was attempted using two protocols ('Mexican' protocol and 'CRI' protocol). The callusing frequency of different genotypes varied from 36-68 %. However no significant difference in callusing was observed among the different genotypes with the 2 protocols tested. Callus obtained could be successfully multiplied by repeated subculture. Induction of somatic embryogenesis and plant regeneration using 'Mexican' protocol was not successful while 20 plantlets were regenerated with the 'CRI' protocol.

Investigations on multiplication of immature embryo-derived callus was continued and it was possible to multiply callus by 4-fold. Application of glutamine (2.7 mg /L) for plant regeneration gave encouraging results. With this treatment, the maximum number of shoots obtained from callus of a single embryo was 22.

It was clearly seen that the response of both plumule and immature embryo explants (in terms of callusing and regeneration potential) varied widely with the type of charcoal used in culture media and the genotype of the explant.

The ovary culture protocol was further improved and a significant increase in shoot regeneration frequency was achieved by incorporating 2iP, BAP and GA3 in to the germination medium. Attempts were also made to identify possible molecular markers to determine the embryogenic potential of ovary cultures with the use of in-situ hybridization technique.

The results obtained from anther culture experiments were quite promising. The optimum density of anthers for induction of androgenesis was determined. Furthermore, a clear correlation between the orientation of the anthers cultured and embryoid formation was identified. The effect of several carbon sources on androgenesis was tested and sucrose was shown to be the best source of carbon. The results also revealed that the concentration of sucrose is critical for successful androgenesis. Detailed investigations on combined effect of 2,4-D with

other auxins (picloram, IAA and NAA) and cytokinins (2iP, zeatin and kinetin) were conducted and the findings were useful in enhancing the frequency of embryogenesis further.

The ploidy level of the embryoids and plantlets derived from anthers was tested using flow cytometry. The results revealed that some of the plantlets were haploid. This is the first time that haploid plantlets were produced from coconut anthers.

The project on cryopreservation of coconut plumules and mature zygotic embryos (conducted in collaboration with IRD, France) was completed successfully. The effectiveness of ABA (in combination with sucrose) as a cryoprotectant for cryopreservation of plumules transported /stored in solidified agar and KCl was investigated. The highest rate of survival and recovery of frozen plumules was observed in those treated with 20 μ M ABA. The results further revealed that the plumules transported /stored in solidified agar have a higher rate of survival and recovery than that of KCl. Cryopreservation of plumules obtained from five different coconut varieties (Sri Lanka Tall, Dwarf Red, D X T hybrid, Bodiri and Gon thambili) was attempted with the new protocol developed. The highest rate of survival and recovery of frozen plumules were observed in D X T hybrid. The recovery rates of Bodiri and Gon thambili were very low and in the case of Dwarf Red, none of the frozen plumules could be recovered.

Rapid propagation of several high-value crops through tissue culture was also attempted. The selected crops were banana (cultivar 'Nethrampalam'), pineapple and some ornamental plants (4 commercial varieties of *Quisqualis indica*, *Ananas comosus*, *Combretum comosum* and *Cordyline terminalis*). Both banana and pineapple could be successfully micropropagated and some of the in vitro-raised plants are at acclimatization stage. The two commercial varieties of *Quisqualis indica* and *Cordyline terminalis* could be propagated in vitro and further experiments are in progress to increase the multiplication rate. Different culture conditions are being tested to develop efficient in vitro regeneration protocols for the other 2 ornamental plants.

2. RESEARCH PROJECTS

PROJECT 18: STUDIES ON THE VEGETATIVE PROPAGATION OF COCONUT

18.1: In vitro culture of coconut embryos

Experiment 18.1.1: Propagation of dikiri pol using the embryo culture technique (1992)

A total of 302 Dikiri embryos were cultured during the year and 140 in vitro-raised plants were transferred to soil for acclimatization. Forty one embryo-cultured Dikiri plants were distributed among growers. A demonstration plot of Dikiri plants was established at Middeniya Research Center.

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Experiment 18.1.6: Cryopreservation of coconut embryos and plumules

The project on cryopreservation of coconut plumules and mature zygotic embryos (conducted in collaboration with IRD, France) was completed successfully.

Previous studies indicated that ABA, in combination with sucrose act as an effective cryoprotectant. Further, studies conducted to identify the most suitable method to transport/ store mature zygotic embryos for cryopreservation work revealed that the plumules excised from embryos stored in KCl (16.2 g/L) and solidified agar (0.45%) has a significant effect on recovery when compared to albumen cores (solid endosperm). Thus suitability of ABA as a cryoprotectant for cryopreservation of plumules transported/stored in solidified agar and KCl was investigated, using encapsulation/dehydration method. Different levels of ABA (0, 10, 20 and 40 μM) were tested in combination with 0.75 M sucrose.

Table 1: *Mean percentage of survival and recovery of frozen and unfrozen plumules (excised from embryos transported/stored in solidified agar)*

Concentration of ABA in pretreatment solution (μM)	Mean percentage survival +D		Mean percentage recovery +D	
	-LN	+LN	-LN	+LN
0	21	52	5	10
10	58	48	48	21
20	58	77	47	55
40	55	50	55	35

+ D- Dehydration + LN- frozen in liquid nitrogen - LN - not frozen

As shown in Table 1, in all 3 treatments with ABA, the survival rate of unfrozen plumules (excised from embryos transported/stored in solidified agar) was over 50%. The highest survival rate of frozen plumules (77%) was observed with 20 μM ABA.

Table 2: *Mean percentage of survival and recovery of frozen and unfrozen plumules (excised from embryos transported/stored in KCl)*

Concentration of ABA in pretreatment solution (μM)	Mean percentage survival + D		Mean percentage recovery + D	
	-LN	+LN	-LN	+LN
0	0	16	0	6
10	12	21	12	11
20	33	41	23	18
40	10	41	11	0

+ D- Dehydration + LN- frozen in liquid nitrogen - LN - not frozen

In the case of unfrozen plumules transported/stored in KCl, the highest survival rate (41%) was observed with 20 and 40 μ M ABA whereas the highest rate of recovery (18%) in frozen plumules was observed with 20 μ M ABA (Table 2). Thus the results clearly indicated that highest rate of survival and recovery of frozen plumules was observed in those pretreated with 20 μ M ABA. The results further revealed that the plumules transported /stored in solidified agar have a higher rate of survival and recovery than that of KCl.

Cryopreservation of plumules obtained from five different coconut varieties (Sri Lanka Tall, Dwarf Red, D X T hybrid, Bodiri and Gon thambili) was attempted with the new protocol developed. The plumules were excised and encapsulated in sodium alginate. The pretreatment solution comprised of 1.0 M sucrose and 20 μ M ABA.

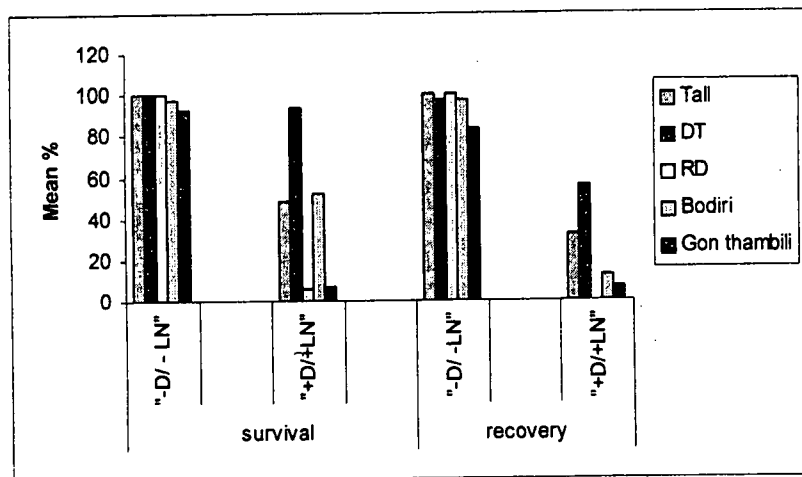


Figure 1: *Effect of cryopreservation on plumules excised from different coconut varieties.*

As shown in Fig. 1, the highest rate of survival and recovery of frozen plumules were observed in D X T hybrid. The recovery rates of Bodiri and Gon thambili were very low and in the case of Dwarf Red, none of the frozen plumules could be recovered.

H D D Bandupriya and S C Fernando

Experiment 18.1.7: Exchange of coconut germplasm through embryo culture

Field planting of 93 exotic coconut plants was accomplished during the year. Fifty three of them were raised from embryos of 6 coconut varieties brought from Ivory Coast whereas the rest were obtained from embryos of 7 varieties collected from PNG. Twenty two plants obtained from PNG and Ivory Coast material are ready for field planting whereas 27 more plants are at different stages of acclimatization. Only a limited number of plants could be raised from the varieties brought from Ivory Coast (Polynesia Tall, Tagnanan Tall, Vanuatu Tall, Tacunan Green Dwarf, Tahitian Tall, Niuleka Green Dwarf, Tenga Tall, Malayan Red Dwarf, West African Tall and Catigan Green Dwarf) due to very poor germination of embryos and 159 of them are still growing in culture.

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18.2. Studies on clonal propagation of coconut

Experiment 18. 2. 1. In vitro culture of immature zygotic embryos of coconut

Variations in callusing were observed with different types of activated charcoal as a result of differences in the amount of 2,4-D (present in the culture medium) adsorbed by them. The change in callusing percentage was used as an indicator to estimate the adsorption capacity of a particular type of charcoal. Based on the observations, the 2,4-D concentration in the culture medium was adjusted to achieve a higher percentage of callusing. The callusing could be increased from 11% to 70 % by changing the 2,4-D concentration from 100 to 150 μ M.

Multiplication of immature embryo-derived callus (by following 'Mexican protocol') was attempted and it was possible to multiply callus by 4-fold. Application of glutamine (2.7 mg /L) for plant regeneration gave encouraging results. With this treatment, the maximum number of shoots obtained from callus of a single embryo was 22.

V Vidhanaarachchi and E S Santha

Experiment 18. 2. 4. Culture of floral meristem explants (1995)

When crushed immature male flowers of -4 inflorescence were cultured in different basal media (72, Y3 and AA), production of small, whitish structures that resemble callus could be observed. However, attempts to grow them further failed. Since these structures appeared to arise from the anthers, further investigations were conducted by direct culturing of immature anthers instead of male flowers. Different methods of explant preparation and pretreatment as well as physical status of culture medium were tested for induction of callogenesis in cultured anthers. However, none of the treatments were effective in eliciting a positive response in the cultured anthers

S C Fernando and H D D Bandupriya

Experiment 18. 2. 5. Culture of plumule explants (1997)

Two independently developed plumule culture protocols ('CRI protocol' and 'Mexican protocol') were tested using plumules of local coconut varieties (Sri Lanka Tall, Dwarf yellow x Tall [DY x T], Dwarf yellow and DT clone). The plumules were excised directly from fresh, mature zygotic embryos. The intact plumules and cultured in basal medium Y3 supplemented with 600 μ M 2,4-D and 0.25% (w/v) activated charcoal (Sigma C 6289) ('Mexican protocol') while crushed plumules were cultured in medium 72 supplemented with 100 μ M 2,4-D and 0.1% (w/v) activated charcoal (BDH 33033) ('CRI protocol').

The embryogenic callus production in plumules of different coconut genotypes varied from 35.5 % to 67.7 % (Table 3). However, no significant difference in callusing was observed among the different genotypes with the 2 media tested. Callus obtained could be successfully multiplied by repeated subculture. The multiplication rate highly varied but a significant difference in average multiplication rate among genotypes and media was not observed (Table 3).

Table 3: Effect of different media on callusing in plmule explants

Variety of coconut	Response			
	Callusing (%)		Multiplication rate (x)	
	Medium 72	Medium Y3	Medium 72	Medium Y3
Tall	50.3	35.5	1.0 - 3.7 (2.1)	1.7 - 8.0 (3.8)
DY x T	44.4	59.8	2.0 - 2.5 (2.3)	1.3 - 3.0 (2.5)
DY	52.5	67.7	nt	nt
Tissue-cultured DT	58.7	45.4	2.1 - 2.5 (2.3)	1.8 - 7.1 (4.5)
Significance	NS		NS	
CV (%)	35.8		67.8	

nt = not tested; NS = not significant; average multiplication rate is given in parenthesis.

Based on the 'Mexican protocol', highly embryogenic calli were sub-cultured to media supplemented with low auxin: high cytokinin (1:50). The cultures were maintained in light and sub-culturing to the same medium was done at two monthly intervals. However, shoot regeneration was not observed in any of the cultures. Successful plant regeneration was achieved by following the 'CRI protocol' in which embryogenic calli were transferred to media supplemented with 10-25 μM ABA for 5 weeks followed by hormone-free medium for 4 weeks and finally to Y3 medium. Twenty plantlets were obtained with this protocol.

Attempts were also made to improve shoot regeneration by incorporating cytokinin (2ip and CPPU) in to the subculturing media after multiplication stage. Development of somatic embryos was observed in most of the 2ip and CPPU treatments. Complete plantlet regeneration could be achieved after transferring the somatic embryos in to Y3 medium followed by Y3 with 0.35 μM GA3. The callus derived from embryos obtained from clonal coconut plants (variety D X T) were used in this experiment. Interestingly, about 160 shoots were regenerated (in media containing different combinations of 2ip and CPPU) from callus derived from a single embryo of a clonal palm. A few shoots were regenerated from callus derived from another embryo of the same palm. These results clearly indicate a strong genotype effect on regeneration potential. The results also showed that careful selection of embryogenic callus during subculture can overcome the problem of haustorial type tissue development at regeneration phase of the cultures. Furthermore, variable callusing response due to changes in the quality of charcoal used in culture media was observed through out the study.

Experiments on the effect of stress (osmotic, heat, cold and desiccation), physical status of culture medium and auxin combinations on somatic embryogenesis and plant regeneration are in progress.

S C Fernando and V Vidhanaarachchi,

Experiment 18. 2. 7. Studies on coconut anther, unfertilized ovary and ovule culture (1997)

Unfertilized ovary culture

Evaluation of different culture procedures:

In addition to the standard procedure (P1) followed in the laboratory for induction of somatic embryogenesis and shoot regeneration in other coconut explants, four other procedures (P2-P5 as listed below) were tested for induction of somatic embryogenesis and plant regeneration with the aim of enhancing the plant regeneration efficiency. Calli in low 2,4-D medium were used for induction of somatic embryogenesis.

P1. ABA + high agar in CRI 72 medium → ABA + normal agar in CRI 72 medium
→ maturation medium (CRI 72 medium without hormones) →
germination medium (Y₃ with 2,4-D and BAP) (Standard procedure;
Control)

P2. ABA + normal agar in CRI 72 medium → maturation medium (Y₃ without
hormones) → germination medium (Y₃ + 2iP + 2, 4-D + BAP)

P3. ABA + normal agar in CRI 72 medium → maturation medium (Y₃.
without hormones) → germination medium (Y₃ + 2, 4-D + BAP)

P4. Maturation medium (Y₃ without hormones) → germination medium (Y₃ +
2ip + 2, 4-D + BAP)

P5. Maturation medium (Y₃ without hormones) → germination medium (Y₃ +
2,4-D + BAP)

In all 5 procedures (P1-P5) tested, very poor shoot formation was observed even after repeated sub-culture of somatic embryos into the germination medium. Thus all the embryogenic structures (obtained by the 5 procedures) were sub-cultured into germination medium supplemented with 0.35 μ M GA3. Shoot formation was observed in the presence of GA3 and the number increased with continuous exposure to GA3. The shoot production in each procedure has been summarized in Table 4.

Table 4. Shoot regeneration achieved by different culture procedures

Culture procedure 1	Percentage of Shoot regeneration ² (No. of shoots per 100 callus)
P1	2.74
P2	11.04
P3	7.41
P4	85.08
P5	6.83
Contrasts	Chi square
P1 vs P4	31.33****
P2 vs P4	40.47****
P3 vs P4	40.61****
P4 vs P5	40.22****

¹In all five procedures (P1-P5), after repeated sub-culture into the relevant germination media, embryogenic structures were sub-cultured into the germination medium containing 0.35 μ M GA3.

²Average of 2 replicates

Maximum likelihood analysis of variance was significant at 0.0001 ($G^2=125.96$)

As shown in Table 4, higher shoot regeneration was obtained with the 4 new procedures tested (P2, P3, P4 and P5) when compared to the control, P1 (2.74%). The results clearly indicated the positive effect of 2iP on shoot regeneration. The highest percentage of shoot regeneration (85%) was achieved with P4 where ABA was not used for induction of somatic embryogenesis. Based on the results, it can be assumed that induction of somatic embryogenesis begins when calli were first transferred to the low 2,4-D containing medium. Maturation of embryos occurs in hormone-free medium and early exposure of matured embryos to 2iP seems to enhance shoot regeneration. The results indicated that sub-culturing the somatic embryos directly into the germination medium containing a high level of cytokinin (5 μ M 2iP together with 5 μ M BAP) could give rise to shoots at a high frequency (85%) ($p < 0.01$). Even though ABA has been used for induction and maturation of somatic embryos in coconut, present results suggest that it could reduce the conversion of somatic embryos into shoots.

Effect of GA3:

Based on the preliminary results of the previous experiment, the positive effect of GA3 on shoot germination was studied further. After maturation, the somatic embryos were sub-cultured into the germination medium containing different levels of GA3. The result of this experiment has clearly shown that incorporation of GA3 in the germination medium improved the shoot regeneration frequency (Table 5). The optimum concentration of GA3 was found to be 0.45 μ M that gave rise to 40% shoot regeneration.

Table 5. *The effect of GA3 on shoot regeneration in ovary-derived calli*

Concentration of GA3 (μ M)	Shoot regeneration percentage ¹ (No. of shoots per 100 callus)
0 (Control)	5
0.2	15
0.35	10
0.45	40
Contrasts	Chi square
T1 vs T4	4.35*
T 2 vs T4	3.7*
T 3 vs T4	3.7*

¹Average of two replicate each containing 10 individuals (n=10)

*Treatment significantly different at $p \leq 0.05$ level

Maximum likelihood analysis was significant at 0.05 ($G^2=9.06$)

Combined effect of 2ip and GA3:

Taking the results of the above experiments into account, the combination of GA3 and 2ip was further studied to optimize plant regeneration frequency. However, results revealed that combination of the two growth regulators had a negative impact on shoot germination.

Anther culture

Anther density:

The density of anthers in the culture vessel could play an important role in embryogenesis. Thus five densities were tested taking 10 anthers per Petri plate as the lowest. The other densities tested were 20, 30, 40 and 50. The anthers were pre-treated at 38 °C for 6 days prior to inoculation. The results clearly indicated that androgenic induction was affected by the number of anthers ($G^2=9.26$, $P < 0.05$) per Petri plate (Table 6).

Table 6. *The effect of anther density on the production of calli/ embryoids in cultured anthers of coconut*

Anther density (No. of anthers per Petri plate)	Number of calli/ embryoids produced per 100 anthers ¹
10	7.90
20	2.46
30	1.64
40	0.00
50	1.80
Contrast	Chi-Square
10 vs 30	6.09*
10 vs 50	6.74*

Mean of five replicates.

Maximum likelihood analysis of variance was significant at $G^2=9.26$, $P<0.05$

Only the significant contrasts were listed in the table

The number of calli/embryoids produced was significantly higher at a density of 10 anthers when compared to 30 ($G^2=6.09$, $p<0.05$) and 50 ($G^2=6.74$; $p<0.05$) whereas no androgenic response was observed at a density of 40 anthers. At higher anther densities, the browning intensity of the medium as well as the anthers was high. The embryogenic potential of the structures formed at higher anther densities (40-50), was found to be low and they all turned brown at an early stage of development.

Carbon source:

All tissue culture media require the presence of a sugar as the source of carbon and energy that also acts as an osmotic agent. The type as well as concentration of sugar affects the induction of androgenesis. Sucrose is the most commonly used carbon source for in vitro culture media. The use of high level of sucrose has shown to be beneficial for pollen embryogenesis in many crops. However, certain studies have indicated the beneficial effects of using other carbohydrate sources instead of sucrose in anther culture media. Thus the effect of the type and concentration of carbon source was studied by culturing the anthers in sucrose, maltose or glucose supplemented media at the concentrations of 4%, 9%, 12% and 15% (w/v).

The average production of calli/embryoids per 100 anthers cultured in media containing sucrose, maltose and glucose at the concentrations of 4%, 9%, 12% and 15% are indicated in Fig. 2.

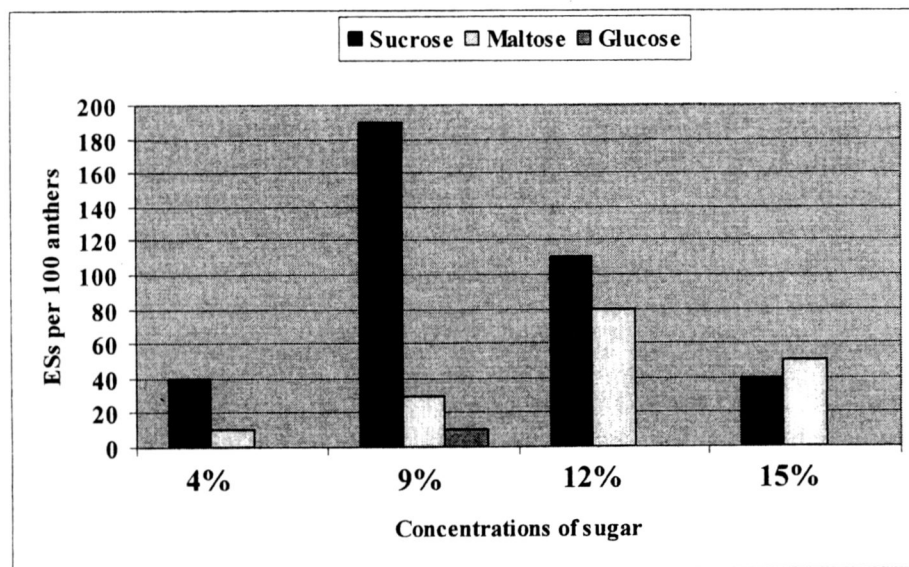


Figure. 2. *Effect of type and concentration of sugars on androgenesis induction in cultured*

Maximum likelihood analysis of variance indicated the importance of the source ($G^2=21.7$, $p<0.0001$) as well as the concentration ($G^2=15.9$, $p<0.01$) of the sugar for androgenic

induction in coconut. Sucrose was shown to be superior when compared to maltose ($G^2=9.27$, $p<0.01$) and glucose ($G^2=14.7$, $p\leq 0.0001$). Sucrose is the carbon source used in media for culture of other coconut explants such as ovary, immature embryo and plumule and it was shown to be suitable for coconut anther culture as well. Glucose seems to have a detrimental effect on cultured anthers and it might be due to high osmotic pressure brought about by glucose.

The results also revealed that the concentration of sucrose in the culture medium has a strong impact on anther response. The frequency of calli/embryoids production could be increased by 5 fold and 3 fold when the sucrose level was increased up to 9% ($G^2=11.51$; $p<0.001$) and 12% ($G^2=8.25$; $p<0.01$) respectively (Table 7). The positive effect of higher sucrose concentration on production of calli/embryoids may be due to its contribution to the osmotic potential of the medium rather than to its utilization as a carbon source. Further increase of sucrose up to 15% has caused a reduction in the formation of calli/embryoids which could be a result of too high osmotic pressure.

Table 7. *Effect of sucrose concentration on induction of androgenesis in cultured anthers of coconut.*

Source	Maximum likelihood analysis of variance
Treatment	15.9**
Contrasts	Chi-square
4% VS 9%	11.51***
4% VS 12%	8.25**
9% VS 15%	6.99**
12% VS 15%	4.06*

Only the significant contrasts were listed in the table

Orientation of anthers:

The effect of the orientation of anthers on androgenesis was tested. The anthers were placed on the culture medium (solidified with 0.65% agar) with their abaxial surface up or down. Three replicates for each treatment were used. The results on the effect of anther orientation on androgenesis are summarized in Table. 8. Maximum likelihood analysis of variance revealed that the orientation of anthers does not significantly affect the percentage of responding anthers and the frequency of calli/embryoids formation. It was also observed that calli/embryoids emerged from both upper and lower surface of the anthers when they were placed with their abaxial surface 'down'. When the anthers were positioned with their abaxial surface 'up', calli/embryoids emerged only from the upper surface. The results further revealed that the percentage of embryoids was significantly higher with the 'up' orientation ($G^2=20.67$ $p<0.0001$) (Table 8). When the growing embryogenic structures touched the culture medium containing 2,4-D, they tend to develop into callus rather than embryoids. Since 2,4-D favours rapid cell proliferation and callus formation, exposure to a high concentration of 2,4-D could lead to formation of callus.

Table 8. Effect of anther orientation on the performance of cultured anthers

Anther orientation	Percentage of anthers responded	Number of calli/embryoids per 100 anthers ¹	Percentage of embryoids ²	Percentage of germinated embryoids ³
Up (T1)	53	230	91.3	17.39
Down (T2)	47	255	41.8	1.96
MLAOV	NS	NS	20.67****	4.73*

¹ Mean of three replicates.

The percentage germination of embryoids could be correlated to the number of embryoids produced as the embryo germination was high with higher production of embryoids. Both the percentage of embryoid formation and germination were significantly higher when the anther orientation was 'up' ($G_2=4.73$; $p<0.05$; $G_2=20.67$; $p<0.0001$).

Effect of growth regulators:

It was shown that 100 μM 2,4-D was effective in inducing androgenesis in cultured coconut anthers. However, the frequency of calli/embryoid formation and their regeneration capacity was shown to be low. On the other hand, induction of embryoids would be beneficial over calli in terms of genetic stability and regeneration frequency. Thus, three auxins (picloram, IAA, NAA) and three cytokinins (2ip, kinetin zeatin) were tested either individually or in combination with 2, 4-D.

Combination of 2, 4-D and other auxins:

The results indicated that picloram and IAA had a negative effect (either alone or in combination with 2,4-D) on androgenesis whereas NAA in combination with 2,4-D promoted calli/embryoid formation. The mean yield of calli/embryoids per 100 anthers and the maximum likelihood analysis of variance for the significant contrasts are given in the Tables 9 and 10 respectively. The highest frequency of calli/embryoids (122) was observed in the medium supplemented with 100 μM 2,4-D and 100 μM NAA (Table.9). However, NAA alone (at 10 or 100 μM) was not effective in enhancing calli/embryoid formation and there was no significant difference among the 2 treatments (T2 and T3) when compared to T1 (medium devoid of any auxins).

Table 9. Effect of different combinations of NAA and 2, 4-D on induction of androgenesis in cultured anthers of coconut

Combinations of 2,4-D and NAA (μM)		Treatment number	Number of calli/embryoids per 100 anthers ¹
2,4-D	NAA		
0	0	T1	14.58
0	10	T2	12.50
0	100	T3	20.84
10	0	T4	31.25
10	10	T5	33.33

Combinations of 2,4-D and NAA (μM)		Treatment number	Number of calli/embryoids per 100 anthers ¹
2,4-D	NAA		
10	100	T6	81.25
100	0	T7	41.68
100	10	T8	64.60
100	100	T9	122.9

¹Mean frequency of 4 replicates

Table 10. *Maximum likelihood analysis of variance and significance of the contrasts.*

Source	DF	Maximum likelihood analysis of variance
Treatment	8	87.55****
Contrasts		Chi-square
T2 VS T5	1	4.2*
T2 VS T8	1	13.56***
T3 VS T6	1	14.75***
T3 VS T9	1	26.95****
T5 VS T6	1	9.01**
T5 VS T8	1	4.62*
T6 VS T9	1	4.02*
T7 VS T9	1	15.6****
T8 VS T9	1	8.42**

Only required significant contrasts were listed in the table.

The frequency of calli/embryoid production was increased with the increase in concentration of NAA from 10 μM to 100 μM in combination with either concentration of 2,4-D (10 μM or 100 μM) (T5 vs T6- $G_2=9.01$; $p<0.01$; T8 vs T9- $G_2=8.42$; $p<0.01$). The best performance of anthers was observed with 100 μM 2,4-D and 100 μM NAA (T9) than the other combinations of 2,4-D and NAA (T6 and T8) ($G_2=4.02$; $p<0.05$ and $G_2=8.42$; $p<0.01$ respectively). These results clearly indicated that NAA in combination with 2,4-D has a significant effect on induction of androgenesis in coconut anthers.

Combination of auxin and cytokinin:

According to the results, higher concentrations of 2ip and kinetin in combination with 2,4-D enhanced the capacity of androgenesis than 2,4-D alone. Out of the 2 cytokinins, kinetin was shown to be more effective and in combination with 100 μM 2,4-D, it gave rise to the highest frequency of calli/embryoid formation. In contrast, zeatin (at the 2 levels tested) could not enhance androgenesis in cultured anthers.

Maximum likelihood analysis of variance was significant for the treatments at 0.01 levels ($G_2=15.98$) (Table 11). The results clearly indicated that 2ip at the concentration of 5 μM was not effective in inducing or enhancing pollen embryogenesis either alone or in combination with 100 μM 2,4-D ($G_2=14.47$; $p<0.0001$). However, at a higher concentration (10 μM) it had a

positive effect on induction of androgenesis and in combination with 100 μM 2,4-D ($G_2=3.73$; $p<0.05$), gave rise to the highest frequency of calli/embryoid production (Table 11).

Table 11. *Effect of 2iP in combination with 2,4-D on the formation of calli/embryoids in cultured coconut anthers and significance of the contrasts*

Combinations of 24-D and 2ip	Number of calli/embryoids per 100 anthers ¹
100 μM 2,4-D (T1)	55.0
5 μM 2ip (T2)	0.0
10 μM 2ip (T3)	65.0
100 μM 2,4-D + 5 μM 2ip (T4)	22.5
100 μM 2,4-D+ 10 μM 2ip (T5)	92.5
Contrastes	Chi-square
T1 VS T4	5.1*
T1 VS T5	3.73*
T4 VS T5	14.47****

¹ Mean of four replicates.

Maximum likelihood analysis of variance was significant at 0.01 ($G_2=15.98$)

Only required significant contrasts were listed in the table

Maximum likelihood analysis of variance was significant for the treatments at 0.01 ($G_2=13.64$). The frequency of calli/embryoid production was significantly higher when kinetin was incorporated into the androgenesis induction medium (T1) either at 5 μM ($G_2=8.12$; $p<0.01$) or 10 μM ($G_2=13.58$; $p<0.001$) (Table 12) level and the latter gave rise to the highest frequency.

Table 12. *Effect of kinetin in combination with 2,4-D on the formation of calli/embryoids In cultured coconut anthers and significance of the contrasts*

Combinations of 24-D and kinetin (KN)	Number of calli/embryoids per 100 anthers ¹
100 μM 2,4-D (T1)	37.5
100 μM 2,4-D + 5 μM KN (T2)	90.0
100 μM 2,4-D+ 10 μM KN(T3)	112.5
Contrasts	Chi-square
T1 VS T2	8.12**
T1 VS T3	13.58***

¹ Mean of four replicates.

Maximum likelihood analysis of variance was significant at 0.01 ($G_2=13.64$).

Only significant contrasts were listed in the table

Maximum likelihood analysis of variance ($G_2=17.65$) was significant at 0.01 level. As shown in Table 13, zeatin (at the 2 levels tested) could not enhance androgenesis in cultured

anthers ($G_2=9.14$; $p<0.01$) either alone or in combination with 2,4-D and the highest frequency of calli/embryoid production was observed in the medium containing 100 μM 2,4-D.

Table 13. *Effect of zeatin in combination with 2,4-D on the formation of Calli/embryoids in cultured coconut anthers and significance of the contrasts*

Combinations of 24-D and Zeatin	Number of calli/embryoids per 100 anthers ¹
100 μM 2,4-D (T1)	55.0
1 μM ZN (T2)	2.5
2.5 μM ZN (T3)	2.5
100 μM 2,4-D + 1 μM ZN (T4)	47.5
100 μM 2,4-D+ 2.5 μM ZN (T5)	45.0
Contrastes	Chi-square
T1 VS T2	9.14**
T1 VS T3	9.14**

¹ Mean of four replicates. Maximum likelihood analysis of variance was significant at 0.01 ($G_2=17.65$). Only significant contrasts were listed in the table

Ploidy level:

The ploidy level of the embryoids and plantlets derived from anthers was tested using flow cytometry. The results revealed that some of the plantlets were haploid. This is the first time that haploid plantlets were produced from coconut anthers.

P I P Perera and L K Weerakoon

Experiment 18. 2. 14. Micropropagation of high-value crops (2002)

Attempts were made to develop suitable culture conditions for in vitro propagation of banana (cultivars 'Nethrampalam' and 'Angaweera'). Shoot tips were used as explants and sterilization was achieved by soaking them in 20% NaOH for 20 min. Prior to culture, the excised shoot tips were dipped in a solution containing ascorbic acid (100mg/l) and citric acid (150 mg/l) to reduce browning. Browning of cultured shoot tips was further reduced by repeated subculture into fresh medium at weekly intervals. Initial culture establishment was achieved in MS medium with 5mg/l BAP. A high rate of shoot multiplication was achieved with to 20 mg/l BAP but the shoots developed showed aberrant growth. Therefore, lower concentrations of BAP (10 and 15 mg/l) are being tested for induction of multiplication. Rooting could be induced by culturing single shoots in MS medium supplemented with 5 mg/l BAP and 1 mg/l IAA. Over 100 in vitro-raised banana plants were transferred to soil for acclimatization and some of them have already been established in the field.

As the initial step in establishing suitable culture conditions for micropropagation of pineapple, various sterilization methods using different combinations of 70% alcohol, Clorox (5-100%), Rifampicin (7.5- 15.0 mg/ml) and calcium hypochlorite (3-5 %) were tested using

axillary buds as explants. About 30-50 % survival was recorded by soaking stems in 70 % alcohol and 25 % Clorox for 30 min. followed by repeated sterilization of axillary buds in 2 % Clorox for 10 min. This was further improved (above 70 %) by washing the buds with Rifampicin prior to culture. Hundred percent survival was achieved by dissecting axillary buds with minimal extra tissues. However, very poor or slow growth was observed in all the cultures. Use of alcohol in sterilization could be a reason for the suppressed growth in cultured buds. Thus alternative sterilization methods were tested.

Sterilization of defoliated stems in a mild solution of Clorox (5 %) for one hour and fine dissection of axillary buds (under stereo binocular) afterwards was found to be very effective in establishing cultures. With this method, survival of buds was 62 % and all the cultures showed satisfactory growth. Suitable culture conditions were developed for shoot multiplication and 190 in vitro-raised pineapple plants were transferred to soil for acclimatization. Further studies are in progress to improve the multiplication rate and growth of plants.

In vitro multiplication of *Cordyline terminalis* ('Count dracula') was tested and axillary buds from field-grown plants were used as explants. Initial culture establishment was achieved in MS solid medium supplemented with 10 mg/l BAP. The shoots were then transferred to MS liquid medium supplemented with 10 mg/l BAP to enhance multiplication. Multiplied shoots were isolated and cultured in MS medium (semi-solid) supplemented with 10 mg/l BAP and further multiplication was observed in the semi solid medium. Charcoal was incorporated to the culture medium to induce shoot elongation and rooting.

A commercial variety of *Quisqualis indica* ('Double petal') could be propagated in vitro and further experiments are in progress to increase the multiplication rate. Different culture conditions are being tested to develop efficient in vitro regeneration protocols for 2 other ornamental plant species, *Ananas comosus* ('Alba') and *Combretum comosum*.

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T R Gunathilake, K P I E Ambagala
and E S Santha*

3. ACKNOWLEDGMENTS

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REPORT OF THE COCONUT PROCESSING RESEARCH DIVISION

J.M.N. Marikkar, PhD

Officer-in-charge

1. GENERAL

The research program of the Coconut Processing Research Division during the year 2006, has given more emphasis on product development, process improvement and machinery development activities.

As a part of the research program, 'dikiri' coconuts studies were conducted to estimate the pectin content of the endosperm. Based on 'dikiri' kernel, jam, ice cream, bread spread, and different other types of sweet meats were prepared and evaluated.

Virgin coconut oil is a unique product out of coconut. A study was conducted to compare the frying stability of virgin coconut oil with those of ordinary coconut oil and refined corn oil. The results showed that virgin coconut oil demonstrated much better stability than ordinary coconut oil and corn oil.

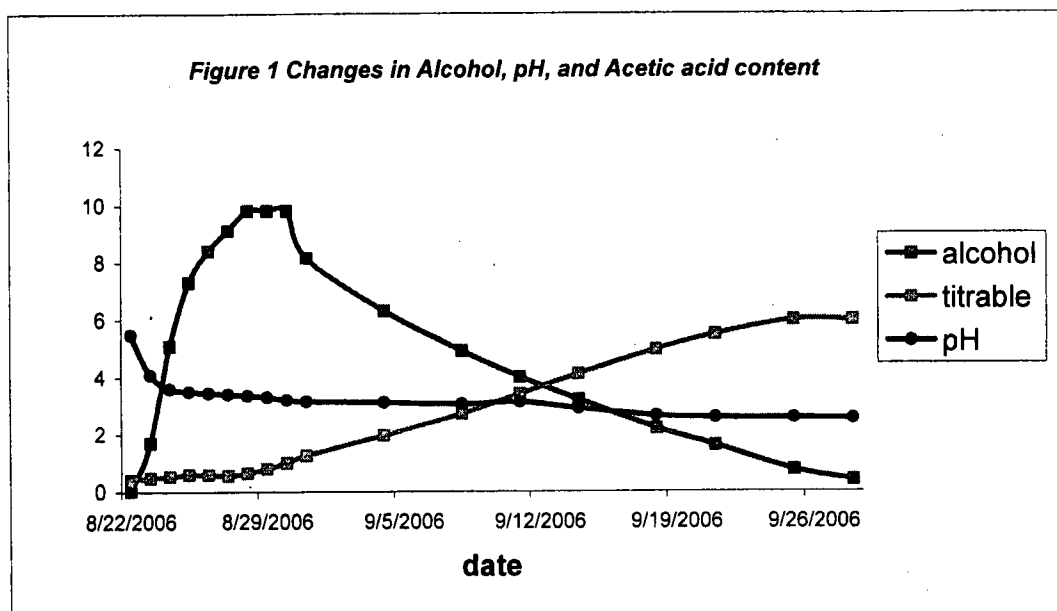
By product utilization is an important aspect to enhance the income generation of the processing sector. The coconut haustorium (*Palapi*), for instance, is part of the germination process and a fair amount of haustorium (*Palapi*) is wasted during the processing of coconut. A study was conducted to use it as a raw material to develop value added products. Preliminary investigations showed that osmotic dehydrated chips could be developed out of haustorium (*Palapi*) and the product can be stored at ambient conditions up to 3 months. Similarly, virgin coconut oil production gives a defatted kernel of high economic value. Therefore, studies were under taken to utilize it in the preparation of fiber-enriched biscuits.

Technology was upgraded for conversion of seasoned-coconut water into vinegar. In order to overcome the delay in acetic fermentation stage, adoption of the generator process was found to be more productive.

Under machinery development program, attempts were made to fabricate low-cost machinery for the promotion of virgin coconut oil. In this respect, a pin cutter machine was fabricated to pulverize coconut kernel while a screw-press low-heating expeller was fabricated to extract oil under mild temperature conditions.

Experiment 01: Adoption of Generator Process for Coconut Water-based Vinegar

Vinegar is a condiment used as an additive for the preparation of various dishes. Coconut water wasted in copra and desiccated coconut manufacture could be converted into vinegar. The process basically involves two distinguished fermenting steps, namely, alcoholic and acetic fermentations. Although alcoholic fermentation is faster and more efficient, the acetic fermentation step is too slow and takes more than a month for completion. The changing nature of the alcoholic content and acid value of the fermenting mixture during the conventional process is shown in Figure 1.



Final acetic acid contents of vinegar samples with reference to four initial brix levels in coconut water are shown in the Table 1.1.

Table 1.1: *Treatments and obtained results of coconut water*

Treatment	Maximum Titaratable acidity (%)	Time duration (days)
1. 12 ⁰ brix	4.02	7
2. 15 ⁰ brix	4.63	16
3. 17 ⁰ brix	5.95	29
4. 20 ⁰ brix	5.62	41

Since the Treatment 3 having 17⁰ brix was found to gain maximum titaratable acidity within relatively low time period, it was selected for the test trial on the vinegar generator. The results showed that the acetic fermenting stage could be completed within three cycles with the acidic level reaching 4%.

Vinegar generator consists of a feeding device, an acetifier and a receiving trough. The acetifier is usually filled up with maize cobs soaked in the mother vinegar sample. Sample of yeast from the fermented coconut water was applied onto the vinegar generator to accelerate the vinegar generating process. While testing the vinegar generator, parameters such as acid value and pH were monitored by two hourly intervals (Table 1.2).

Table 1.2: *Average changes of acetic acid level and pH during the Generator Process at the four hours cycle*

Trial	Acetic acid level (%)	pH
Starter	3.5	3.44
1 st round	3.29	3.01
2 nd round	3.47	2.93
3 rd round	4.81	2.90

CRI vinegar generator was designed to provide the maximum surface exposure for volume of vinegar stock in order to supply excess of air to the acetic acid forming bacteria to efficiently and quickly oxidize the alcohol to acetic acid. According to the results obtained, coconut water vinegar gained 4 - 4.8% of acetic acid strength during 3 - 4 cycles (Table 1.2). The maximum time period taken for the process was 48 hours and by controlling the feeding rate of the substrate into acetifier, we can match the oxidation rate and almost complete conversion to acid was achieved. While normal vinegar making procedure take 37 days to obtain maximum vinegar strength, vinegar generator process taking not more than 48 hours. According to the SLSI specification (SLS 168:1999), the total acidity (as acetic acid) of coconut water vinegar should be in between 4 - 13% (m/v).

K.D.P.P.Gunathilake & J.A.K.M.Fernando, D.S.Jayawickrama

Experiment 02: *Development of Value Added Products Using 'Dikiri' Coconut*

Dikiri coconut containing soft gelatinous endosperm is found in few numbers in some coconut trees mainly in the southern province of Sri Lanka. This kind of coconuts has not been fully exploited to develop new food products. Therefore, the objective of this research was to determine physico-chemical properties of 'dikiri' coconut and to identify its potential for value addition. The proximate composition of the 'dikiri' coconut is shown in Table 2.1

Table 2.1: *Proximate composition of 'dikiri' coconut*

Chemical constituents	Dikiri	Ordinary Tall
moisture	61.2 ± 0.96	55.37 ± 0.32
Ash	1.22 ± 0.1	0.81 ± 0.07
Crude fat	59.81 ± 3.68	66.44 ± 6.64
Crude fibre	17.65 ± 0.24	16.39 ± 0.23
Crude protein	6.64 ± 0.33	7.84 ± 0.22
Other Carbohydrates	14.69	8.52

The results presented in Table 2.2 show that the 'dikiri' coconut kernel contains 22.36% pectin, 10.01% acid detergent fiber (ADF), 27.39% neutral detergent fiber (NDF), 3.50% lignin, 17.38% hemicelluloses, 6.51% cellulose as dietary fiber.

Table 2.2: Dietary fiber content of dikiri coconut

Analysis	Dikiri coconut (%) (DW %)	Ordinary coconut (DW %)
ADF	10.01	13.78
NDF	27.39	20.51
Lignin	3.50	6.69
Hemicellulose	17.38	6.73
Cellulose	6.51	7.00
Pectin	22.3	-

Abbreviations: ADF, acid detergent fiber; NDF, neutral detergent fiber.

Similarly, results further showed that mineral (Table 2.3), vitamin C contents (Table 2.4) and fatty acid profile of 'dikiri' kernel (Table 2.5) were similar to those of normal ordinary coconut.

Table 2.3: Mineral composition of 'dikiri' coconut

Element	Dikiri coconut (% db)	Normal coconut (% db)
Na	0.15+/- 0.02	0.11+/-0.002
K	2.58+/-0.04	2.91+/-0.04
Ca	0.023+/-0.0014	0.06+/- 0.007
Mg	0.36+/-0.009	0.42+/-0.053

Table 2.4: Vitamin C content of Dikiri Coconut

Vitamin	Dikiri coconut	Ordinary coconut
Vitamin C	2.32mg/100g	2.10mg/100g

Table 2.5: Fatty acids profile of dikiri coconut compare with TxT & DxT

Fatty acids	Dikiri Coconut (%)	TxT	DxT
C6:0	0.62	1.41	1.03
C8:0	8.07	7.93	7.69
C10:0	5.91	4.21	4.97
C12:0	47.41	44.45	47.06
C14:0	17.04	21.62	19.28
C16:0	8.55	10.46	8.72
C18:0	1.98	1.34	0.80
C18:1	7.92	6.01	6.26
C18:2	2.49	3.91	4.19

So far 'dikiri' based products such as jam, ice-cream, bread spread, and different types of sweets were developed.

K.D.P.P.Gunathilake

Experiment 03: Preparation of dietary fiber from Coconut Residue Left in the Extraction of VCO

Defatted coconut flour left in the extraction of VCO has a potential for dietary fiber. The objective of this study was to isolate dietary fiber out of defatted coconut flour and to utilize it in cookies to increase their dietary fiber content. The flour contained moisture, fat, protein, crude fiber and ash (Table 3.1). It is fairly rich in protein and soluble sugars and these are needed to be removed to obtain coconut fiber.

Table 3.1: Composition of Coconut Flour

Component	Content (g/100g)
Moisture	3.69
Fat	13.43
Ash	5.12
Protein (N x 6.25)	21.76*
Total sugars	18.80*
Crude fiber	9.27*

* Fat free basis

Analysis of the defatted coconut flour showed that it contained various fiber components such as crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicelluloses and cellulose. The coconut flour contained 38.26 per cent NDF out of which 24.23 per cent is ADF and 14.02 per cent is hemicelluloses. These results indicated that coconut fiber is mainly the NDF type, in which ADF is a major fraction. It also contained appreciable amount of hemicellulose and cellulose (Table 3.2).

Fiber component	Content (%)
Crude fiber	9.30
Neutral detergent fiber	38.26
Acid detergent fiber	24.23
Hemicellulose	14.02
Cellulose	10.30

Table 3.2: *Fiber Composition of Coconut Flour*

The food grade fiber was isolated from the coconut flour by treating the defatted flour with NaOH at pH 13 and 80 % aqueous ethanol at 80°C. The isolated fiber contained 81.36 % neutral detergent fiber. Out of this 44.5 % were acid detergent fiber and 36.86 % hemicelluloses (Table 3.3).

Table 3.3: *Fractionation of Coconut Fiber*

Components	Content (%)
Crude fiber	23.11
Neutral detergent fiber	81.36
Acid detergent fiber	44.5
Hemicellulose	36.86
Cellulose	16.1
Ash	1.23

The fiber isolate was incorporated in preparation of cookies. The cookies were organoleptically acceptable up to substitution level of 20 %.

Experiment 04: Development of Products Using Coconut Haustorium (*pelapi*)

The coconut haustorium, which is known as *Palapi* in Sinhala is discarded during processing of seasoned coconut. The haustorium (*Palapi*) is palatable at early stages of germination. It is sweet in taste and has about 6 hours of shelf life at room temperature. A study was carried out to determine the nutritional composition of the haustorium and to deduce the optimum condition to prepare dehydrated chips out of coconut haustorium. Germinated coconuts of four different stages obtained from Coconut Research Institute nurseries were selected for this study. The stages of germination of the seedling were determined from the visual size of the shoot. The chemical analysis showed that it contained 88.2 – 91.2 % moisture, 0.83 – 1.24 % ash, 0.71 – 1.70 % protein, 1.35 -2.91 % fat, 0.53 – 0.82 % crude fibre and 1.35 – 2.91 % sugar (Table 4.1). The fat from haustorium showed that it contained 4 – 6 % oleic acid, 47 – 50 % lauric acid and 21 % myristic acid. Fatty acid content did not vary with the stages of germination and the composition shows very close to coconut oil (Fig. 4.1). Total plate counts were 9×10^3 , 5×10^3 , 4×10^3 , and 2.5×10^3 CFU (Colony Forming Unit) / g at cut opening for 1st germination stage to fourth stage respectively. Plate count increased when it was exposed to ambient conditions. After 6 hours the plate counts were 1.1×10^5 , 2.1×10^5 , 4.5×10^5 , and 1.2×10^5 CFU/ g for 1st germination stage to fourth stage respectively.

Table 4.1: Composition of Fresh Haustorium at Various Stages of Germination

Germination stage	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Total sugars (%)
1	88.2	0.83	2.91	0.71	0.62	4.79
2	88.9	0.92	1.74	1.15	0.53	3.32
3	90.0	0.88	1.6	1.59	0.78	3.07
4	91.2	1.24	1.35	1.70	0.82	1.93

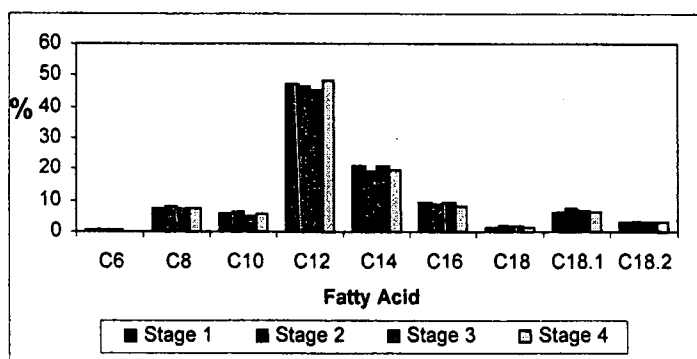


Figure: Fatty acid composition of fat from coconut haustorium with different stages of germination

Table 4.2: Different treatments of preparation of dehydrated chips

Treatment	Size of pieces (cm ³)	Sugar : haustorium (w/w)
A	1 × 1 × 4	1 : 1
B	1 × 1 × 4	½ : 1
C	1 × 1 × 1	1 : 1
D	1 × 1 × 1	½ : 1
E	1 × 1 × 1	-
F	1 × 1 × ½	-

Two preservation methods namely, direct dehydration and osmotic dehydration were carried out for the preservation of haustorium. Six treatments (Table 4.2) with different sizes of the chips and different ratios of sugar to Haustorium (w/w) were carried out in the preservation studies. All the samples were dehydrated at 65 ° C for 7 ½ hours and the temperature was increased up to 75 ° C during the last 20 -30 minutes to give crispness to chips.

Kruskal Wallis one-way nonparametric ANOVA test showed that there was a significant difference with regard to the organoleptic qualities among chips from different treatments. Osmotic dehydration obtained higher scores on sensory evaluation than the direct dehydration. Out of different treatments for osmotic dehydration, 1 x 1 x 4 cm³ size; 1:1 sugar: haustorium ratio obtained highest score for overall acceptability (Fig. 4.2). Initial study showed that the osmotic dehydrated chips could be stored at ambient conditions up to 3 months.

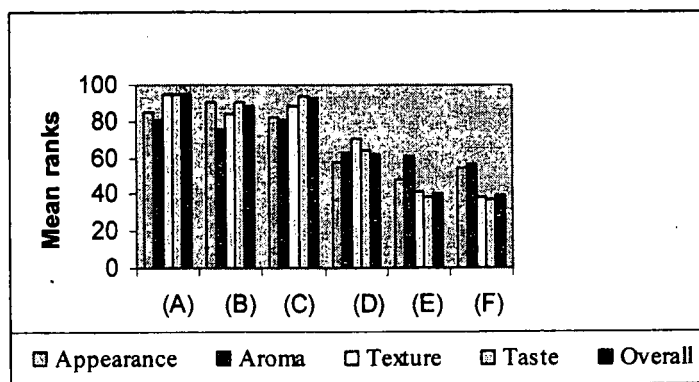


Figure 4.2 Mean Rank of Treatments according to Sensory Attributes

C. Yalagama and R A M K Ramanayake

Experiment 05: Identification of Microbes Enhancing the Coconut Husk Retting Process

Retting is the preliminary step of extracting brown and white fibre for the coir industry. This conventional retting process takes around six to twelve months period. Therefore, it is necessary to develop an appropriate technology to reduce the retting period to improve the productivity in coir fibre industry.

In this study coconut husk samples and the ret liquor samples collected after retting from the fresh, saline & brackish water were subjected to microbiological and physico-chemical analysis. Altogether, twelve micro-organisms responsible for retting were isolated and identified as given in Table 5.1.

Table 5.1: Retting Enhancing Microbes

No.	Species name
1	Bacillus polymixa
2	Bacillus firmus
3	Bacillus subtilis
4	Kurthia
5	Serratia liquifaciens
6	Bacillus badius
7	Bacillus Sphaericus
8	Bacillus macerans
9	Escherichia coli
10	Enterobacter spp
11	Micrococcus varians
12	Pseudomonas varians

Physico-chemical Analysis of ret liquor was also done for Ret-liquor samples collected after retting in fresh saline & brackish water as given in Table 5.2. (Three samples were collected at bimonthly intervals)

Table 5.2: Physico-chemical Analysis of Ret-liquor

Sample	N(mg/l)	P(mg/l)	K(mg/l)	Na(mg/l)	Mg(mg/l)	Ca(mg/l)
Fresh water 1	5.46	2.62	168.9	60.9	2.4	4.1
Fresh water 2	4.06	3.91	448.9	107.0	3.5	5.3
Fresh water 3	4.06	3.73	447.0	76.5	2.6	4.2
Brackish Water 1	1.68	6.94	891.0	89.5	28.2	34.9
Brackish Water 2	1.40	9.37	1392.1	287.2	26.1	18.3
Brackish Water 3	1.82	10.45	1157.1	266.5	19.6	10.8
Saline Water 1	150.0	0.075	507.5	8512.0	208.7	48.75
Saline Water 2	150.0	0.225	540.0	9031.0	227.5	53.75
Saline Water 3	220.0	0.432	570.0	9262.0	235.0	57.5

Laboratory –Scale Experiment: Laboratory scale experiment design to select pectin degrading and phenol decomposing microorganisms at CRI

Retting trials were being continued for the coconut husks of variety CRI C60. In the first trial the coconut husks were soaked in distilled water and then inoculated with above isolated micro-organisms. It is done for replicates and aerobic plate counts were taken for each 4 weeks for all replicates. From the 2nd trial the effective micro-organisms utilized in retting process were identified according to the pith content adhering on the surface of the mattress fibre. The identified retting enhancing microbes are given in Table 5.3

Table 5.3: Most Effective Retting Enhancing Microbes

Sample No	Treatment
12	Pseudomonas varians
13	Mixed culture
06	Bacillus badius
02	Bacillus firmus
05	Serratia liquifaciens
08	Bacillus macerans

The trials are in progress. In this, parameters namely texture, pith content, tensile strength of mattress fibre will be evaluated to identify the most efficient retting enhancing microbes.

S. Mallawarachi, J.A.K.M. Fernando, & U. Dushanthi

Experiment 06: Development and Improvement of coconut fibre based products

Coconut fiber products have a great potential in domestic and international market in view of the world trend towards natural products. Coconut coir has extremely desirous qualities to qualify as a raw material for a range of products and purposes. Development and improvement of coconut coir products are essential in gaining a premium price for such products.

In this study a coir defibering machine and a coir press machine were fabricated for the manufacture of products such as weed control mats, turfs, coir poly bags etc. In the subsequent step, the project will be extended for the manufacture of coir composites.

J.A.K.M. Fernando & J.R. Kelum

Experiment 07: Utilization of Defatted Coconut Kernel Residue as Raw Material for Preparation of Fibre-enriched Biscuits

Defatted coconut flour (DCF) obtained from the whitish kernel residue left after the extraction of virgin coconut oil has potential application in high protein-fiber enriched food products. A study was conducted to investigate the use of defatted coconut flour in the preparation of fiber-enriched biscuits. In this, wheat flour (WF) was fortified with DCF in varying proportions (w/w, 0, 10, 20, 30, 40, 50, 60, and 70%) to prepare a series of blends for biscuit dough. Biscuits samples were prepared according to a standard recipe (Table 7.1). Biscuit samples so prepared were evaluated by a 36-member semi-trained panel using a 7-point hedonic scale to determine the critical limit of DCF substitution in WF for acceptable quality biscuits (Table 7.2). Proximate composition of biscuit samples was determined (Table 7.3). Biscuit samples were checked for keeping quality for a period of 3 months (Tables 7.5 & 7.6).

Table 7.1. Recipes of biscuit formulation with different treatments

Treatment	Wheat Flour(g)	Coconut Flour(g)	Margarine(g)	Sugar(g)	Baking Powder(g)	Egg(g)	Water(ml)
T0	500	0	250	200	20	80	0
T1	450	50	250	200	20	80	0
T2	400	100	250	200	20	80	0
T3	350	150	250	200	20	80	0
T4	300	200	250	200	20	80	100
T5	250	250	250	200	20	80	200
T6	200	300	250	200	20	80	250
T7	150	350	250	200	20	80	300

Table 7.2. Sensory attributes of biscuit samples with different treatments

Treatment	Appearance	Texture	Taste	Smell	Overall acceptability
T ₀	164.0 ^a	197.0 ^a	196.0 ^a	154.5 ^a	178.5 ^a
T ₁	170.0 ^a	200.5 ^a	212.0 ^a	169.5 ^a	184.5 ^a
T ₂	160.5 ^a	195.0 ^a	204.0 ^a	195.5 ^a	173.5 ^a
T ₃	185.0 ^a	195.0 ^a	189.0 ^a	174.0 ^a	180.5 ^a
T ₄	192.0 ^a	170.5 ^{a,b}	176.0 ^{a,b}	175.0 ^a	158.0 ^{a,b}
T ₅	136.0 ^a	128.0 ^{b,c}	111.5 ^b	136.0 ^a	110.0 ^b
T ₆	132.5 ^a	99.5 ^{b,c}	99.0 ^b	138.0 ^a	100.5 ^b
T ₇	156.0 ^a	110.5 ^c	108.0 ^b	153.5 ^a	102.5 ^b
Significance	ns	***	***	ns	***

¹Means in the same column bearing different letters are significantly different from each other. Abbreviations: ns, not

Significant, ***, $p < 0.001$, $N = 36$

Friedman test for the sensory attributes showed that there was no significant difference between the control and the different levels of DCF incorporated samples with respect to appearance and smell. This confirms that the different levels of DCF substitution for wheat flour do not have any direct impact on the appearance and smell. With regard to taste, texture and overall acceptability there was no significant difference between the control and the DCF substituted biscuit samples up to the level of 40 % substitution. It can be confirmed that DCF could be used to substitute WF up to a level of 40 % without affecting the overall quality. Based on the sensory evaluation study, it was decided to limit the DCF substitution up to 40 %.

Table 7.3: Proximate composition of biscuit samples of different treatments (g/100 g dry matter basis) ¹

Treatment	Moisture	Ash	Protein	Fat	Crude Fiber	Soluble Sugar	Other Carbohydrates (by difference)	Energy (KJ/Kg)
T ₀	1.72 ^a	1.49 ^a	5.93 ^a	20.82 ^a	0.60 ^a	24.66 ^a	44.77 ^a	2043.61 ^a
T ₁	2.06 ^b	1.67 ^b	8.31 ^b	22.46 ^b	2.5 ^b	27.86 ^a	35.15 ^b	2037.52 ^a
T ₂	2.34 ^c	1.99 ^c	8.99 ^b	22.93 ^b	3.65 ^c	28.35 ^a	31.74 ^b	2018.18 ^a
T ₃	2.58 ^c	2.19 ^d	10.80 ^c	23.70 ^c	5.30 ^d	30.84 ^a	24.60 ^{b,c}	2018.18 ^a
T ₄	3.02 ^d	2.44 ^e	12.36 ^c	24.90 ^d	6.10 ^e	32.29 ^a	18.88 ^c	1599.42 ^a
P Value	0.0004	<0.0001	0.0013	<0.0001	<0.0001	0.4061	0.0215	1599.76 ^a
								0.5448

¹Means in the same column bearing different letters are significantly different from each other. P value ($p < 0.05$) significantly different.

Crude fiber, Moisture and ash contents were significantly different between the control and the treated samples. At 40 % substitution level, the crude fiber content of the biscuit was found to increase by about 10 times. Although there was difference in values of soluble sugar contents between the control and DCF-fortified biscuit samples, the difference was statistically non-significant. However, with regard to carbohydrate content a significant decrease was noticed between the control and DCF fortified samples. Energy values show no significant difference among treatments.

Table 7.4 *Changes in moisture, free fatty acid, and peroxide value of biscuit samples with time¹*

Treatment	Time (weeks)						
	0	2	4	6	8	10	12
Moisture (%)							
T ₀	1.72 ^a	2.95 ^b	3.18 ^c	3.48 ^d	3.89 ^e	4.61 ^f	5.50 ^g
T ₁	2.06 ^a	2.72 ^b	2.97 ^b	3.65 ^c	4.16 ^d	4.44 ^d	5.43 ^c
T ₂	2.34 ^a	2.58 ^b	2.86 ^c	3.28 ^d	3.71 ^e	3.81 ^e	4.14 ^f
T ₃	2.58 ^a	2.87 ^b	3.21 ^c	3.86 ^d	4.16 ^e	4.88 ^f	5.10 ^f
T ₄	3.02 ^a	3.13 ^a	3.32 ^a	3.87 ^b	4.21 ^c	5.23 ^d	5.64 ^c
Free fatty acids (% palmitic)							
T ₀	0.24 ^a	0.28 ^a	0.42 ^b	0.54 ^c	0.58 ^d	0.64 ^e	0.78 ^f
T ₁	0.26 ^a	0.30 ^b	0.43 ^c	0.58 ^d	0.61 ^e	0.66 ^f	0.79 ^g
T ₂	0.33 ^a	0.34 ^a	0.44 ^b	0.59 ^c	0.62 ^c	0.69 ^d	0.81 ^e
T ₃	0.34 ^a	0.42 ^b	0.50 ^c	0.63 ^d	0.66 ^d	0.75 ^e	0.84 ^f
T ₄	0.34 ^a	0.48 ^b	0.52 ^b	0.64 ^c	0.70 ^d	0.78 ^e	0.86 ^f
Peroxide value (meq/kg)							
T ₀	1.49 ^a	3.00 ^b	4.26 ^c	6.88 ^d	8.56 ^e	9.88 ^f	12.51 ^g
T ₁	1.99 ^a	4.18 ^b	4.30 ^b	7.21 ^c	9.37 ^d	10.90 ^e	11.96 ^f
T ₂	2.99 ^a	4.31 ^b	4.42 ^b	7.76 ^c	9.49 ^d	10.50 ^e	11.46 ^f
T ₃	3.99 ^a	4.68 ^b	5.08 ^c	8.18 ^d	9.78 ^e	11.25 ^f	12.58 ^g
T ₄	4.42 ^a	4.99 ^b	5.31 ^c	8.50 ^d	10.62 ^e	11.02 ^f	12.92 ^g

¹Each value in the table represents the mean of duplicate analyses. Means in the same column bearing different letters are significantly different from each other

With time keeping quality of any food item may be affected and thereby its quality characteristics such as taste, smell, colour and texture can be deteriorated. In order to monitor the keeping quality of biscuit samples, moisture content, free fatty acid content and peroxide values are useful parameters. Particularly, moisture absorption is a critical factor which might affect the longer storage stability of biscuits. According to the data presented in Table 7.4, the moisture content of the control and the DCF fortified samples increased slightly. However, during the entire storage period, none of the samples exceeded the 6 % limit prescribed by the standardization agencies (SLS 251:1991; BIS 1974). The increase in FFA content of all the biscuit samples was very minute. Similarly, only a slight variation was observed in peroxide values of samples.

Table 7.5 Changes in aerobic plate count and yeast and mould count of biscuit samples with time¹

Treatment	Time (Weeks)						
	0	2	4	6	8	10	12
Aerobic plate count (CFU/g)							
T ₀	4.51×10 ^{2a}	5.35×10 ^{3b}	1.05×10 ^{4c}	1.75×10 ^{4d}	2.55×10 ^{4f}	3.10×10 ^{4f}	3.75×10 ^{4g}
T ₁	4.30×10 ^{2a}	5.15×10 ^{3b}	9.75×10 ^{3c}	1.60×10 ^{4d}	2.10×10 ^{4e}	2.60×10 ^{4f}	3.25×10 ^{4g}
T ₂	3.85×10 ^{2a}	5.15×10 ^{3b}	9.40×10 ^{3c}	1.50×10 ^{4d}	2.20×10 ^{4e}	2.60×10 ^{4f}	3.45×10 ^{4g}
T ₃	3.95×10 ^{2a}	4.90×10 ^{3b}	9.45×10 ^{3c}	1.40×10 ^{4d}	1.85×10 ^{4e}	2.40×10 ^{4f}	3.55×10 ^{4g}
T ₄	3.90×10 ^{2a}	4.75×10 ^{3b}	9.10×10 ^{3c}	1.25×10 ^{4d}	1.80×10 ^{4e}	2.10×10 ^{4f}	3.05×10 ^{4g}
Yeast and mould count (CFU/g)							
T ₀	7.85×10 ^{1a}	1.45×10 ^{2a,b}	3.05×10 ^{2b,c}	4.10×10 ^{2c,d}	5.25×10 ^{2d}	7.00×10 ^{2e}	9.55×10 ^{2f}
T ₁	1.15×10 ^{2a}	1.85×10 ^{2a,b}	3.55×10 ^{2b,c}	4.90×10 ^{2c}	6.95×10 ^{2d}	9.20×10 ^{2e}	1.15×10 ^{3f}
T ₂	1.45×10 ^{2a}	2.05×10 ^{2a}	4.60×10 ^{2b}	5.30×10 ^{2b}	7.45×10 ^{2c}	1.35×10 ^{3d}	1.45×10 ^{3d}
T ₃	1.60×10 ^{2a}	2.25×10 ^{2a}	3.80×10 ^{2b}	5.40×10 ^{2c}	9.45×10 ^{2d}	1.75×10 ^{3e}	2.05×10 ^{3f}
T ₄	1.90×10 ^{2a}	2.30×10 ^{2a}	4.25×10 ^{2b}	5.40×10 ^{2b}	1.05×10 ^{3c}	2.05×10 ^{3d}	2.45×10 ^{3e}

¹Each value in the table represents the mean of duplicate analyses. Means in the same column bearing different letters are significantly different from each other. Abbreviation: CFU, Colony Forming Units

Micro flora usually affects most of the food items and therefore, it is very necessary to monitor their growth during storage. The data presented in Table 7.5 show a slight variation in aerobic plate count and yeast and mould count of biscuit samples during the 3 months of storage. However, the variation is within the tolerable limits. The pattern of variation is similar between the control and the DCF fortified samples.

It can be concluded that DCF can be used in fiber enriched biscuits up to a level of 40 % without affecting the sensory quality adversely and the stability of biscuits for three months under ambient conditions.

J. M. N. Marikkar, J.M.M.A Jayasundera & D. Rupanjali

Experiment 08: Assessment of the Stability of Virgin Coconut Oil during Deep-frying

Virgin coconut oil (VCO) is a unique product out of coconut. Since there is a growing market for VCO in the international trade, information on the frying stability would be useful for producers, traders and end-users. A study was conducted to compare the frying stability of VCO with those of ordinary coconut oil (CNO) and refined corn oil (CO). Each oil sample was placed separately in an electrically operated open fat fryer and heated at 180 °C for a period of 8 h. During frying, samples were withdrawn from the fryer at specified time intervals to monitor the changes in free fatty acid (FFA) content, peroxide value (PV), total polar compound (TPC) and anisidine value (AnV) using standard test methods. Results presented in Tables 8.1, 8.2, 8.3, & 8.4, showed that there was a tendency for the increase of FFA, PV, TPC, and AnV of all three oils. However, the values of these parameters corresponding to VCO were found to be the lowest through out the 8 h frying operation.

Table 8.1. Progressive change in free fatty acid values of frying oils¹

Oil	During the First Hour of Frying (min)					During the Eight Hours of Frying (h)			
	0	15	30	45	60	2	4	6	8
VCO	0.0294 ^a	0.0334 ^b	0.0349 ^b	0.0374 ^c	0.0388 ^c	0.041 ^d	0.058 ^e	0.070 ^f	0.089 ^g
CNO	0.0695 ^a	0.0716 ^b	0.0749 ^c	0.0788 ^c	0.0825 ^d	0.090 ^e	0.099 ^e	0.129 ^f	0.139 ^g
CO	0.0970 ^a	0.1074 ^b	0.1092 ^b	0.1152 ^c	0.1170 ^c	0.116 ^c	0.130 ^d	0.142 ^e	0.150 ^f

¹Means within each row with different superscript are significantly different ($p < 0.01$).

Abbreviations: VCO, virgin coconut oil; CNO, coconut oil; CO, corn oil.

Table 8.2. Progressive change in peroxide values of frying oils¹

Oil	During the First Hour of Frying (min)					During the Eight Hours of Frying (h)			
	0	15	30	45	60	2	4	6	8
VCO	N.D.	0.498 ^a	0.788 ^b	0.908 ^b	1.065 ^c	1.326 ^d	3.657 ^e	4.748 ^f	5.200 ^g
CNO	1.538 ^a	1.985 ^b	2.447 ^c	2.669 ^d	2.818 ^e	4.370 ^f	7.016 ^g	9.830 ^h	10.334 ⁱ
CO	7.655 ^a	7.805 ^b	8.000 ^c	8.305 ^d	8.415 ^e	8.991 ^e	9.620 ^f	10.232 ^g	10.976 ^h

¹Means within each row with different superscript are significantly different ($p < 0.01$).

Abbreviations: N.D., not detected; For other abbreviations see Table 8.1.

Table 8.3. Progressive change in anisidine values of frying oils¹

Oil	During the First Hour of Frying (min)					During the Eight Hours of Frying (h)			
	0	15	30	45	60	2	4	6	8
VCO	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.812 ^a	2.385 ^b
CNO	N.D.	N.D.	N.D.	N.D.	N.D.	0.350 ^a	3.202 ^b	7.423 ^c	8.523 ^d
CO	1.868 ^a	2.491 ^b	3.173 ^c	4.223 ^d	6.415 ^e	9.247 ^f	15.687 ^g	19.369 ^h	24.183 ⁱ

¹Means within each row with different superscript are significantly different ($p < 0.01$).

Abbreviations: See Tables 8.1 and 8.2.

Table 8.4. Progressive change in total polar compound values of frying oils¹

Oil	During the First Hour of Frying (min)					During the Eight Hours of Frying (h)			
	0	15	30	45	60	2	4	6	8
VCO	1.61	2.13	2.94	3.38	3.49	4.38	10.07	13.00	14.68
CNO	3.10	3.38	4.00	4.47	5.38	8.00	11.71	16.34	17.97
CO	8.91	9.45	9.72	10.00	10.43	12.05	15.67	19.26	20.63

¹Abbreviations: See Table 8.1.

Since TPC is used as a reference parameter to determine the rejection point of frying oils, prediction models were also developed for TPC using simple regression analysis. Based on the prediction models, the rejection points of VCO, CNO, and CO were found to be 13.45, 10.95 and 10.25 respectively.

J. M. N. Marikkar, J.M.M.A Jayasundera & H. Prasadika

Experiment 09: Evaluation of Locally-fabricated Pin-cutter for Production of Dried Comminuted Kernel

Dry processing of VCO, involves production of dried comminuted kernel and screw pressing of the dried kernel for oil extraction. Therefore, there is a dire need for an efficient pin-cutter machine to produce dried comminuted kernel. The particle size of the dried comminuted kernel should be comparable to the medium sized desiccated coconut particles available commercially. In this study, a locally-fabricated pin-cutter machine was assessed through field trials to see its efficiency. The machine consists of two different kinds of cutters, which are operated by 0.25 HP electric motors. The first cutter helps to disintegrate coconut kernel from bigger pieces to smaller pieces. It is equipped with precision ground concentric cutting teeth and blades fixed on a revolving drum and mounted horizontally into a screw type conveyer and is wide open to a funnel for the feeding of wet kernel. The cut pieces coming out of this are passed onto the second cutter through the screw type conveyer. Being mounted vertically to the conveyer, the second cutter has its blades fixed onto a revolving drum to produce medium size kernel particles. When wet coconut kernel pieces are introduced to the center of the rotating unit, they are shredded and thrown towards the periphery by centrifugal action. Finally, the vertically mounted blade of the cutter helps to expel the pulverized kernel particles into a collection vessel kept in the right bottom. According to the results, the machine has a throughput capacity of 400 nuts per hour. Analysis of particle size distribution showed that a randomly selected sample contained 86.15% medium sized particles and 13.85% larger particles.

Table 9.1: *Particle size distribution in the dried pulverized kernel sample*

Trial number	Medium size particle (%)	Large size particle (%)
1	86.43±0.88	13.57±0.88
2	85.43±1.47	14.57±1.47
3	86.64±0.22	13.36±0.22
Mean ± SD	86.16±0.64	13.84±0.65

On the other hand, examination of the commercial samples of DC showed that it contained 100 % medium size particles. It is due to the fact that in commercial DC operation, after completion of drying, the whole product is conveyed on to an inclined vibratory mesh and screen where over burnt and charred particles are removed manually and in the subsequent step, the product is sorted into different particle sizes namely course, medium size, and fine particles by a grading machine.

J. M. N. Marikkar, J.M.M.A Jayasundera & C. Jayawickrama

Experiment 10: Evaluation of Locally-fabricated Screw-press Expeller for Virgin Coconut Oil Extraction

Availability of a suitable screw-press expeller is vital for the dry processing of virgin coconut oil. In this study, a locally-fabricated screw-press machine having two worm shafts was assessed through field trials. In commercial VCO production, extraction efficiency and throughput capacity are two important parameters which determine the productivity. According to field trials, the machine has a operational capacity of 35 Kg of DC per hour when running in the dual worm shaft operation. When running on a single worm shaft, the machine has the capacity of 18 Kg of DC per hour (Table 10.1).

Table 10.1. Comparison of the Extraction capacity of locally fabricated and imported machines

Worked worm shaft	Locally fabricated machine (Kg of DC/ hr)	Imported machine (Kg of DC/ hr)
Left worm shaft run	18.75 ^a	14.65 ^b
Right worm shaft run	17.65 ^a	13.35 ^b
Dual run	35.30 ^a	30.0 ^b

According to the data in Table 10.1, the operational capacity of the locally fabricated machine is significantly higher than that of the imported machine. The main reason for the difference is the fact that in the imported machine at least two extractions are needed to recover the maximum amount of oil from the dried kernel sample. But using the locally fabricated machine, the same amount of oil could be recoverable within one single extraction. This time reduction in operation could be the main reason for the higher operational capacity of the locally-fabricated machine. The oil outputs from left and right worm shafts, when running singularly, were 720 ml/Kg and 752

ml/Kg, respectively. During a dual worm shaft operation, the machine was found to have a crude oil recovery of 750 ml/Kg (Table 10.2).

Table 10.2. Comparing the recovery of crude oil and defatted kernel residue out of the locally fabricated and imported machines

Worked worm shaft	Locally Fabricated Machine		Imported Machine	
	Crude oil (ml / kg of DC)	Defatted oil cake (g / kg of DC)	Crude oil (ml / kg of DC)	Defatted oil cake (g / kg of DC)
Left worm shaft run	720.0 ± 4.0	320.9	746.0	304.4
Right worm shaft run	752.0 ± 6.9	300.9	741.0	294.5
Dual run	750.6 ± 1.5	304.0	752.0	298.6

According to the data in Table 10.2, there is no significant difference between the locally fabricated machine and the imported machine with respect to the crude oil recovery and the amount of defatted kernel residue produced.

J. M. N. Marikkar, J.M.M.A Jayasundera & A. Dharmasena

Experiment 11: Characterization of Different Lauric Oils

A study was carried out to find out the characteristics (fatty acid composition, iodine value (IV), slip melting point (SMP), free fatty acid (FFA) content, peroxide value (PV), moisture content (MC) and colour) of 5 different oils namely, virgin coconut oil (VCO), normal coconut oil (CNO), king coconut oil (KCO), coconut paring oil (CPO) and palm kernel oil (PKO) (tables 11.1 and 11.2).

Table 11. 1. Fatty Acid Composition of Different Lauric Oils¹

Fatty Acid (%)	Different Lauric Oils				
	VCO	KCO	CPO	CNO	PKO
Caproic (C _{6:0})	0.19 ± 0.02	0.08 ± 0.02	0.06 ± 0.06	0.27 ± 0.10	0.24 ± 0.24
Caprylic (C _{8:0})	7.30 ± 0.43 ^a	4.74 ± 0.27 ^b	5.85 ± 0.35 ^b	6.80 ± 0.38 ^a	3.84 ± 1.59 ^c
Capric (C _{10:0})	5.86 ± 0.46 ^a	4.27 ± 0.21 ^b	4.30 ± 0.37 ^b	5.33 ± 0.17 ^a	3.56 ± 0.99 ^b
Lauric (C _{12:0})	50.76 ± 0.11 ^a	48.45 ± 2.39 ^a	43.67 ± 1.13 ^b	48.29 ± 0.86 ^a	44.84 ± 3.14 ^b
Myristic (C _{14:0})	19.60 ± 0.09 ^a	19.96 ± 0.58 ^a	20.81 ± 0.37 ^a	19.94 ± 0.20 ^a	17.11 ± 1.49 ^b
Palmitic (C _{16:0})	7.27 ± 0.64 ^c	9.93 ± 1.03 ^a	10.66 ± 0.58 ^a	8.89 ± 0.44 ^b	10.43 ± 1.74 ^a
Stearic (C _{18:0})	1.37 ± 0.54 ^b	1.59 ± 0.60 ^b	3.44 ± 1.65 ^a	1.21 ± 0.15 ^b	2.53 ± 0.40 ^a
Oleic (C _{18:1})	4.66 ± 0.39 ^c	7.74 ± 7.74 ^b	8.95 ± 1.41 ^b	6.52 ± 0.72 ^b	14.97 ± 3.18 ^a
Linoleic (C _{18:2})	3.00 ± 0.35 ^a	3.23 ± 0.25 ^a	2.25 ± 0.23 ^b	2.73 ± 0.17 ^b	2.46 ± 0.26 ^b

¹ Figures within each row with different superscript are significantly different (p<0.05)

Abbreviations: VCO, Virgin Coconut Oil; KCO, King Coconut Oil; CPO, Coconut Paring Oil; CNO, Ordinary Coconut Oil; PKO, Palm Kernel Oil. Each value is a mean of four replicates.

VCO, KCO and CNO showed significantly higher lauric acid contents than those of PKO and CPO. PKO showed the highest oleic acid (C_{18:1}) content (14.97 ± 3.18 %) and it was the lowest for VCO (4.66 ± 0.39 %). Linoleic acid (C_{18:2}) was significantly higher in KCO and VCO than those of other oils.

Table 11.2. Analytical Parameters of Different Lauric Oils¹

Oil	IV \pm SD	SMP($^{\circ}$ C) \pm SD	FFA (as lauric acid %)+SD	PV(meq/Kg) \pm SD	MC (%)+SD	Colour(Y+5R) \pm SD
VCO	6.42 \pm 0.71 ^a	25.0 \pm 0.0	0.07 \pm 0.02 ^a	ND \pm 0.00 ^a	0.13 \pm 0.04	ND \pm 0.00 ^a
KCO	11.10 \pm 0.17 ^b	25.8 \pm 0.27	0.21 \pm 0.02 ^c	ND \pm 0.00 ^a	0.14 \pm 0.02	0.10 \pm 0.14
CPO	11.75 \pm 0.33 ^c	25.5 \pm 0.0	0.40 \pm 0.12 ^c	0.13 \pm 0.05 ^b	0.16 \pm 0.05	0.40 \pm 0.28
CNO	8.84 \pm 0.27 ^d	25.3 \pm 0.29	0.33 \pm 0.06 ^c	ND \pm 0.00 ^a	0.12 \pm 0.03	0.90 \pm 0.99
PKO	15.86 \pm 0.18 ^e	26.5 \pm 1.37	0.11 \pm 0.04 ^b	0.24 \pm 0.04 ^c	0.14 \pm 0.06	0.14 \pm 0.06 ^b

SD-Standard Deviation, Y-Yellow, R-Red, ND-Not Detected

¹ Figures within each column with different superscript are significantly different ($p < 0.05$).

Each value is a mean of four replicates.

A significant difference in IV was observed for all the oils, while the highest (15.86 \pm 0.18) was reported for PKO and the lowest (6.42 \pm 0.71) was for VCO. Acceptable levels of IV for VCO, CNO and CPO are 6-7, 7.5-11 and 9-18 respectively (SLS specifications) and it is 13-23 for PKO (Bockish,1993). All lauric samples had the IV in an acceptable range. There was no significant difference in MC and SMP of all five oils. Lauric oils having more or less similar fatty acid profile may be the reason for non significant SMP. The MC varied between 0.12 \pm 0.03 and 0.16 \pm 0.05 % while SMP varied from 25 \pm 0.0 to 26.5 \pm 1.39 $^{\circ}$ C for all the oils. VCO showed the lowest FFA value (0.07 \pm 0.02%) and the highest FFA value was observed for CPO (0.40 \pm 0.12 %). However, no significant difference in FFA was observed among KCO, CPO and CNO. VCO showed a significantly lower colour when compared to that of PKO. PKO showed peroxide value of 0.24 \pm 0.04 meq/kg, which was the highest value observed among the oils. No PV was observed for VCO, CNO and KCO.

J.M.M.A Jayasundera, J.M.N Marikkar & D.Nissanka

Experiment 12: Development of Heat Recovery Unit for Production of Good Quality Charcoal and Dried Pulverized Kernel

In Sri Lanka, charcoal production is mostly done by the traditional pit firing process. In this method, lot of heat is wasted and the smoke emitted causes environmental pollution. Hence, it is very essential to develop alternative technology to replace the existing pit firing method. In this project, a prototype gasifier unit was developed using locally available raw materials where crushed coconut shells are used as fuel source. According to initial test trials, a combustible producer gas was generated, which upon passing on to a burner gave a yellowish red colored flame. The temperature of the flame was found to be around 800 $^{\circ}$ C. The heat generated by the flame can be profitably used for dehydration requirements of the coconut processing industries. Further work is in progress.

J. R. Kelum & J. M. N. Marikkar

REPORT OF THE PLANT PHYSIOLOGY DIVISION
Head – C S Ranasinghe, Ph D

1. GENERAL

Research programme of the division was conducted using the consolidated fund and the coconut CESS fund. Evaluation of hybrid vigour of dwarf crosses revealed a significantly higher rate of photosynthesis and instantaneous water use efficiency (A/E) in four hybrids namely DGxSR, DBxT, TxDB and DBxSR compared to the rest of varieties under favourable soil moisture conditions. Out of them, DGxSR showed a 40% higher rate of photosynthesis compared to the mean of the rest of varieties tested. Evaluation of the performance of same varieties at different agro-ecological regions is in progress.

A long-term experiment at Wanathavilluwa (DL3) (S2 with Gambura and Mavillu series) was started last year to determine the effect of irrigation on the vegetative growth, flowering time and yield under different land suitability classes. Regular monitoring and data collection are in progress. The rain water harvesting project that started last year primarily intended to construct small rain water harvesting tanks for collecting runoff in CRI estates (nine sites – Middeniya, BE, PRS, Ambakelle GRC, PSG, RE, WE, Makandura and Maduru Oya). Three such tanks ranging from 270 - 4600 m³ (0.2 - 3.7 acre feet) were constructed at Bandirippuwa estate and post evaluation of the improvement of yield, its consistency and improvement in soil moisture retention during dry spells are yet to monitor. Evaluation of a model drought management system for mini coconut triangle was started at Middeniya Research Centre with the objective to identify an overall drought management package for drought prone areas in the mini coconut triangle. Planting of seedling and application of moisture conservation practices were completed and data collection is in progress.

A study carried out to determine the effect of the soil condition (land suitability class, LSC) on the growth of root system of seedlings, showed a 55% reduction of root length density in five-year old seedlings grown in S4 soil compared to that in S2 soil. The Dwarf x Tall hybrid (CRIC 65) showed a rapid reduction of cell membrane stability (CMS) than that of Tall x Tall (CRIC 60) with the progress of the drought. Severe moisture stress was more effective in improving CMS than mild moisture stress for a similar period in both varieties.

Seven growers/ exporters obtained the protocol for quality preservation of tender king coconuts within the year 2006. Gauge 300 Polyethylene was identified as the best material for vacuum packing of king coconut compared to Nylon-Low Density Polyethylene (N-LDPE) and Normal oriented Polypropylene (Normal OPP). Ten cultivars namely Dwarf Green (DG), Dwarf Yellow (DY), Dwarf Red (DR), Dwarf Brown (DB), Cameroon Red Dwarf (CRD), King coconut (KC), Bodiri (BD), Murusi (MU), Bothal Thembil (BT) and Juvan (JU) were evaluated to identify potential coconut cultivar/s for the tender nut industry. Seven-month old nuts of BD showed 2-fold increase in sucrose and 50% in invert sugar (glucose and fructose) content than the mean of all cultivars. Accordingly, BD contained 50% more overall sugar content in seven-month old nuts. Further one-fold increase of sucrose and about 20% decrease of invert sugars were observed in nut water of BD during the 7 - 8 month period. A study was initiated to compare total sugars and polyphenol content in the soft tissues under the perianth of mite-infested and mite-free nuts in different cultivars.

THRUST AREA: CROP IMPROVEMENT

PROJECT: STUDIES ON FACTORS LIMITING DRY MATTER PRODUCTION IN COCONUT VARIETIES AND HYBRIDS

Experiment: Evaluation of hybrid vigour of Dwarf Brown x Tall, Tall x Dwarf Brown and Dwarf Brown x San Ramon for yield and tolerance to moisture stress in different agro-ecological zones (Raddegoda, RE and Wanathavilluwa)

Some exceptional morphological, vegetative and yield characteristics prompted plant breeders to develop hybrids using Dwarf Brown as one of the parent materials. The presence of characters such as non-seasonality, high yielding capacity (higher number of nuts per bunch and higher no of inflorescence per palm per year) and relatively higher tolerance to water stress conditions compared to those of other dwarf varieties appeared more promising to cross it with other selected tall varieties. The objective of this experiment was to evaluate the 'hybrid vigour' of developed crosses on the basis of their vegetative, physiological, drought tolerant and yield characteristics under different agro-ecological regions.

Hybrids under evaluation:

Dwarf Brown x Tall, Dwarf Brown x San Ramon, Tall x Dwarf Brown
Dwarf Green x Tall, Dwarf Green x San Ramon, Tall x San Ramon
Tall x Tall, Dwarf Brown

DGxSR showed significantly higher ($P < 0.01$; 40%) rate of photosynthesis (A) under favourable weather conditions at Raddegoda (IL3) experimental site (Table 1). Higher stomatal conductance (g_s) of DGxSR indicated that a lesser limitations for gaseous exchange at the stomatal level under favourable conditions compared to the rest of varieties. The observed higher g_s appeared to have contributed for the higher rate of photosynthesis and transpiration (E). Even with higher E , DGxSR managed to maintain comparatively higher instantaneous water use efficiency ($\omega_{inst} = A/E$) along with DBxT, TxDB, DBxSR all of which showed higher A . Higher photosynthetic rate of DGxSR in favourable environmental conditions indicate its potential for higher yields under such conditions. TxT, TxSR and DGxT showed average A and g_s resulting in a comparatively low ω_{inst} under favourable conditions. However, evaluation with long-term data especially under water deficit conditions is imperative prior to any conclusions. Data collection is in progress at Raddegoda site while it is yet to start at Rathmalagara (IL1) and Wanathavilluwa (DL3) sites.

Table 1: Mean rate of photosynthesis (A), stomatal conductance (g_s), rate of transpiration (E) and instantaneous water use efficiency ($\omega_{inst} = A/E$) of different hybrids at Raddegoda.

Variety	A	g _s	E	$\omega_{inst} = A/E$
T x T	5.71 ^{cd} ± 0.40	0.38 ^b ± 0.05	8.31 ^b ± 0.50	0.69 ^{ab} ± 0.06
T x SR	5.43 ^d ± 0.70	0.39 ^b ± 0.05	9.00 ^b ± 0.58	1.59 ^b ± 0.06
DG x T	5.25 ^d ± 0.55	0.37 ^b ± 0.05	8.76 ^b ± 0.53	0.59 ^b ± 0.04
DG x SR	9.25 ^a ± 0.80	0.61 ^a ± 0.12	11.23 ^{ab} ± 0.56	0.82 ^a ± 0.04
DB x T	6.48 ^{bcd} ± 0.53	0.37 ^b ± 0.06	8.40 ^b ± 0.73	0.83 ^a ± 0.11
T x DB	7.46 ^b ± 0.58	0.37 ^b ± 0.04	8.76 ^b ± 0.30	0.85 ^a ± 0.05
DB x SR	7.28 ^{bc} ± 0.66	0.42 ^b ± 0.07	8.73 ^b ± 0.46	0.83 ^a ± 0.06
Significance	**	**	***	**
cv%	16.0	17.5	8.2	14.3

** Significant at P < 0.01, *** P < 0.001

*A Nainanayake, C S Ranasinghe, H C Mendis,
R D N Premasiri, L R S Silva*

Experiment: Coconut Genome mapping (collaborative experiment with GPBD)

A mapping population of coconut was obtained from crosses between single tall pollen donor and 26 genetically identical dwarf mothers by GPBD. Due to the delays in the construction of the plant house, the characterization of seedlings from 26 families using net assimilation rate, water use efficiency and related biochemical parameters under plant house conditions could not be implemented as scheduled. Field planting is scheduled at Walpita Research Station where the physiological characterization will be conducted under field conditions.

A Nainanayake, C S Ranasinghe, S A C N Perera (GPBD)

THRUST AREA: CROP PRODUCTION

PROJECT: STUDIES ON WATER, LIGHT, HEAT STRESS AND ELEVATED CO₂ EFFECTS ON PRODUCTIVITY

Experiment: Effect of irrigation on physiological, vegetative and yield characters of Tall x Tall and Dwarf Green X Tall crosses

Objectives of this study was to identify and quantify potential benefits of irrigation on two commercially available coconut cultivars in different land suitability classes by investigating vegetative growth, physiological and yield characters. This would provide site-specific recommendations for coconut cultivation under irrigation. Two commercially available improved coconut cultivars (CRIC 60 and CRIC 65) were used.

Treatments

- T1 - Control (No irrigation but with general management practices)
- T2 - Irrigation @ 40 liters / palm / day during dry spell
(Irrigation @ 10 liters / palm / day for first two years, 20-30 liters / palm / day until 5 years of age & thereafter 40 liters / palm / day)
- T3 - Irrigation @ 80 liters / palm / day during dry spell
(Irrigation @ 20 liters / palm / day for first two years, 40 liters / palm / day until 5 years of age & thereafter 80 liters / palm / day)

Irrigation is started after a 15 days of continuous rain-free period.

Location 1: Thapal watta, Wanathawilluwa,
DL3 (Latasol & regosol region of the dry low country region)

Soil type and land suitability:

a. *Mavillu series*

S2 (suitable to highly suitable)
Imperfectly drained
Very deep (> 120 cm)
Sandy loam to sandy clay loam soil
Slope approx. 3%
Potential yield 12,500 – 15,000 nuts/ha/year (5,000 – 6,000 nuts/ac/year)

b. *Gambura series*

S3 (suitable)
Well drained
Very deep (> 120 cm)
Sandy loam to sandy clay loam soil
Slope approx. 3%
Potential yield 10,000 – 12,500 nuts/ha/year (4,000 – 5,000 nuts/ac/year)

Physiological, biochemical, vegetative and root growth parameters (No. of roots, rooting depth, root length, root length density) and yield (at later stage) are scheduled to be monitored. Seedlings were planted in early 2006 and all seedlings were uniformly treated until they establish well in the soil. With respect to the vegetative growth parameters (height, girth, number of leaves), no significant differences were observed between varieties, land suitability classes or treatments at the end of the establishment period. This indicated that the uniformity of seedlings prior to impose treatments. Irrigation system is scheduled to establish in the next year and collection of preliminary data is in progress.

A Nainanayake, H C Mendis

Experiment 03: Yield improvement in coconut lands by Rain water harvesting techniques

The intermediate zone of Sri Lanka where coconut is highly concentrated, receives substantial amount of rainfall of high-intensity with short-duration. Due to the surface runoff

more than 70% of water ends up in streams causing soil erosion and nutrient losses. Moreover, when the time gap between two rainy seasons is longer than usual or failures in monsoon rains cause severe water deficits in coconut lands. The collection of such surface runoff for productive purposes without leaving water to cause soil erosion and nutrient loss is termed as the rain water harvesting. Collected runoff water helps to maintain the water table and also replenish deeper soil layers which can be exploited by deeper roots. If the infiltration of the soil is low, surface collection can be utilized for irrigation purposes and also helps to make favourable changes in the microclimate. The objective of this experiment is to construct rain water harvesting tanks with substantial catchment area in CRI estates. The improvement of yields and its consistency in effective area of the surrounding coconut plantation are monitored along with the improvement in soil moisture retention during dry spells.

It is expected to develop a package of site specific recommendations for water harvesting in coconut lands based on quantified effects of harvested water in improving soil moisture content and coconut yield in different agro-ecological regions and different land suitability classes. Three water tanks were constructed at Bandirippuwa estate having capacities of 270 m³ (0.22 acre feet), 1800 m³ (1.60 acre feet), 4600 m³ (3.72 acre feet) in field no 2, 3 and 7 respectively. Relevant block-wise yield data in effective areas of each tank were collected prior to the construction. It is early to comment on effects and monitoring is in progress.

A Nainanayake, A Tennakoon (SPND), N Liyanage (Est. Mgmt)

Experiment 04: Evaluation of a model drought management system in Middeniya research station

Middeniya area in the Hambantota district experiences a substantial dry spell from June to September each year even though the area receives an average rainfall of about 1300 mm with two peak periods in October- December and March-May. Marked reduction in yield due to the effect of drought is a common feature in the area. However, average annual rainfall and its monthly distribution for last two decades reveals that the effects of dry spells can substantially be reduced if proper management practices are adopted. This experiment aimed to develop a new coconut plantation with an overall drought management system (mulching, husk burial, improvement of moisture holding capacity by incorporation of organic material which is amply available in the region, introduction of cover crops (*Peuraria*) and some nitrogen fixing trees (*Gliricidia*)). Altogether this would substantially reduce the impact of the drought. This also would reduce the casualties at seedling stage and improve the growth rate at seedling stage and reduce the yield losses during droughts in the adult stage. All the improved cultivars that CRI has released so far are expected to evaluate under these conditions [Tall x Tall (CRIC 60), Dwarf x Tall (CRIC 65), Tall x San Ramon (CRISL 98), Dwarf Green x San Ramon (Kapruwana) Rumassala (local accession from Southern Province)]. Accordingly, it was expected to assess the growth of seedlings in the model drought management system and it is expected that the experiment will enable to recommend an overall drought management package for drought prone areas in the mini coconut triangle in Southern province in the future. Experimental site will act as an *in situ* demonstration site to convince growers on the potential benefits of the proper management of coconut lands.

Treatments

- a. Control with only fertilizing but without any soil moisture conservation practices
- b. Application of overall soil moisture conservation and improvement practices
Mulching, husk burial (10 x 4 x 4 pits in alternative rows)
Incorporation of organic material (cow dung) for the improvement of soil texture and moisture holding capacity.
Introduction of cover crops and NFTs (*Peuraria* and *Gliricidia*)
- c. Irrigation @ 10 liters per seedling per day during drought period for first 2 years, 20 liters per seedling per day during drought period until the age of 5 years and thereafter 40 liters per palm per day during droughts. Irrigation will be started after a continuous rain-free period of 15 days.

Five coconut cultivars in three blocks under three treatments were planted with 9 seedlings per plot in Randomized Complete Block Design. All plots were separated by a guard row and there were 405 and 372 seedlings in treatment plots and guard rows respectively amounting to a total of 777 seedling. Its planting distance was 26' x 26' square and spreads over 12 acres of land. Seedlings with uniform growth were planted. Application of some soil moisture conservation practices (Organic manure and husk pits) have already been implemented but the construction of the irrigation system is yet to be implemented. No significant differences in vegetative growth (girth, height and number of leaves) was observed between treatments within first few months after planting. It is too early to observe treatment effects.

A Nainanayake, H C Mendis

Experiment 05: The effect of CO₂ elevation in the atmosphere on acclimatization of embryo-cultured plants.

The adaptation of embryo-cultured coconut seedlings grown under laboratory conditions to the external environment is relatively a slow process. This substantially extends the time taken up to field planting. Thus the objective of this experiment was to determine the effect of elevation of atmospheric CO₂ during the acclimatization, on vegetative growth of embryo-cultured coconut plants and thus to improve the acclimatization protocol of embryo-cultured plants. Embryo cultured plants were placed in two open top chambers (4.3 m diameter x 2.8 m height, covered with UV treated polythene) at Bandirippuwa Estate and exposed to either elevated CO₂ (500-550 ppm) or ambient CO₂ (350-360 ppm). Seedlings were transferred into chambers and vegetative growth (leaf production rate, leaf area development and growth of root system) and physiological performance (gas exchange rates) of the plants are being monitored.

C S Ranasinghe, A Nainanayake, L R S Silva

PROJECT: STUDIES ON ROOT GROWTH, ROOT ACTIVITY AND ROOT FUNCTIONS IN RELATION TO WATER AND NUTRIENT UPTAKE

Experiment 06: Investigation of growth performances of Tall x Tall coconut seedlings grown in different land suitability classes, with particular reference to root system.

The study was carried out to determine the effect of the soil condition (land suitability class, LSC) on the growth of root system and its impact on the physiological performance of seedlings. Root samples were collected up to 0.3 m depth from four opposite places in the manure circle of each seedling and composite them. Having separated the large and fine roots in the soil core sample, root diameter, root volume, fresh weight and dry weight were measured in each category and the root density was calculated. Relative Water Content (RWC) of roots were determined separately on primary and secondary roots while leaf RWC was determined simultaneously using leaf samples from the youngest fully expanded leaf.

Root RWC did not show any significant differences between different LSC. However, the leaf RWC was significantly low ($p < 0.001$) in seedlings grown in S_4 soils compared to those grown in S_2 and S_3 soils. The highest root density (dry weight basis) (0.98 gml^{-1}) was observed in seedlings grown in S_2 soils and it differed significantly ($p < 0.001$) from the lowest (0.43 gml^{-1}), observed in S_4 soils after five years growing in the field. Accordingly, seedlings grown in S_4 soils showed more than 55% reduction in root growth with respect to that in S_2 soils. This indicate a substantial impact of the soil condition (LSC) over the seedling performance, specially the below ground part. No significant difference was observed in the rest of parameters monitored. The experiment is in progress.

*W S Madurapperuma, R D N Premasiri,
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Experiment 07: An Investigation of drought tolerance mechanism in coconut (*Cocos nucifera* L); with particular reference to roots

Drought tolerance is a combined effect of many factors such as environment, soil properties, capacity of roots to uptake and transport water, leaf water status and canopy characters. Therefore, the objective of this study is to investigate the drought tolerance mechanism of CRIC 60 under different soil types and agro-climatic zones. Three major adjustments of plants in response to drought *viz.* hydraulic (hydraulic conductivity, percentage of embolism in roots and xylem sap flow), physiological (photosynthesis, rate of transpiration, leaf water potential, stomatal conductance and water use efficiency) and biochemical (starch, sugar and ABA content) were monitored with following objectives.

1. To determine the variation of the above-mentioned parameters in relatively drought-tolerant CRIC 60 and drought-susceptible CRIC 65 in different soil types and agro-climatic conditions;
2. To identify relationships of above parameter to yield and thereby identify key parameters that determine the drought tolerance;
3. To develop a composite index (i.e. a selection index) consisting of key traits to screen coconut palms for drought tolerance.

The entire experiment was consisted of two experiments under plant house conditions and in the field.

The plant house experiment was carried out to observe and quantify the physiological, biochemical and morphological responses of CRIC 60 (TT) and CRIC 65 (DT) for soil water deficit conditions with the objective to understand the responsive mechanisms.

Cell Membrane Stability (CMS) was studied to understand the effect of stress at the cellular level. Membrane dysfunction due to stress is expressed in increased permeability of the membrane and leakage of ions. Thus, the drought tolerance test is based on the measurement of the electrical conductivity of aqueous medium containing leaf discs obtained from the youngest fully expanded leaf. As shown in Fig. 1, CMS of the seedlings started to decline 10 days after the commencement of the drying cycle. CMS declined rapidly in seedlings grown under mild watering compared to those under no watering (severe stress). This reduction was faster in DT than that of TT. Seedlings exposed to severe stress showed higher CMS compared to those stressed mildly at forty-five days of drying. Water conservation due to the marked increase in stomatal diffusive resistance (SDR) in the severely stressed seedlings may have contributed to maintain the cell membrane stability during the middle of the drying cycle and appeared as an adaptation to drought. Quick drying in severely stressed seedlings might have hardened cell membranes to a certain extent. CMS declined in both varieties until 45 days of drying cycle after which, there was an increasing trend. This may have been due to the selection of a new leaf which was developed under the drought condition and that might have resulted in some degree of membrane hardening. At the end of the drying cycle CMS of TT was significantly higher ($p < 0.05$) than that of DT under the same stress level which indicates that TT possesses greater membrane stability over DT.

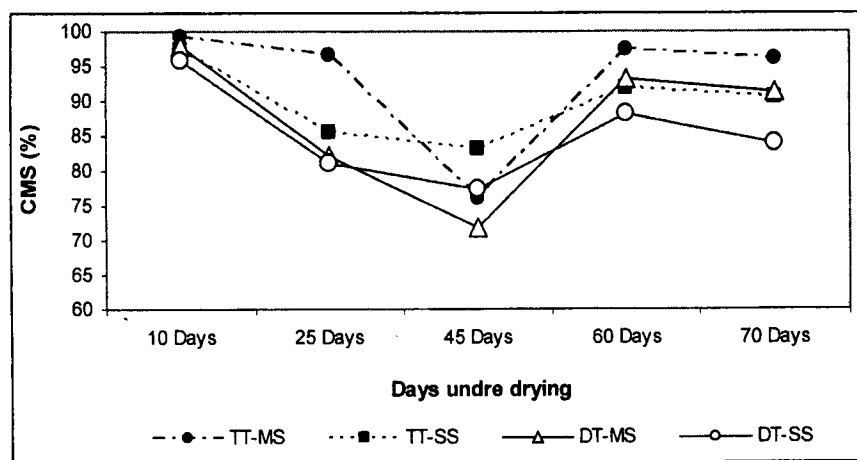


Figure. 1. *Pattern of changing the CMS of CRIC 60 (TT) and CRIC 65 (DT) during the drying cycle.*

Root hydraulic conductivity measurements

Root hydraulic conductivity (Ks) measured at the end of drying cycle of the seedlings grown in the plant house did not show significant difference between varieties (Table 2).

however, native hydraulic conductivity (Kh_{nat}) was significantly affected by the stress. The highest Kh_{nat} was observed under well watered condition in both varieties but reduced with the severity of the stress. This could be due to the formation of vessel embolism. However, Kh_{max} (Maximum hydraulic conductivity) didn't show any significant differences among treatments in both varieties. The percentage loss of conductivity (PLC) was only marginal (1 - 4 %) under well watered condition but increased up to 60- 90% under stressed conditions in both varieties. Similarities in the stomatal regulation patterns of both varieties under the water stress condition could be the reason for the similar patterns of root conductivity observed in both varieties.

Table 2: Native and maximum root hydraulic conductivity (kg MPa⁻¹ m⁻¹ s⁻¹) (Mean ± SE) of the seedlings raised in the plant house under different water treatment levels

Variety	Treatment	Native Conductivity (Kh _{nat})	Maximum Conductivity (Kh _{max})
CRIC 65	Well watered	1.28 ^b x10 ⁻⁴ ± 2.05 x10 ⁻⁵	1.36 x10 ⁻⁴ ± 2.05 x10 ⁻⁵
CRIC 65	Mild Stress	6.07 ^a x10 ⁻⁵ ± 2.05 x10 ⁻⁵	9.82 x10 ⁻⁵ ± 2.05 x10 ⁻⁵
CRIC 65	Severe Stress	7.85 ^a x10 ⁻⁵ ± 2.05 x10 ⁻⁵	7.55 x10 ⁻⁵ ± 2.05 x10 ⁻⁵
CRIC 60	Well watered	1.08 ^b x10 ⁻⁴ ± 2.05 x10 ⁻⁵	9.47 x10 ⁻⁵ ± 2.05 x10 ⁻⁵
CRIC 60	Mild Stress	4.69 ^a x10 ⁻⁵ ± 1.89 x10 ⁻⁵	6.69 x10 ⁻⁵ ± 2.05 x10 ⁻⁵
CRIC 60	Severe Stress	6.37 ^a x10 ⁻⁵ ± 2.05 x10 ⁻⁵	6.50 x10 ⁻⁵ ± 2.05 x10 ⁻⁵

Same letters indicate there is no significant difference

Leaf Water Potential

Leaf Water Potential (LWP) of just after predawn measurements or mid day measurements did not show any significant differences between varieties (Table 3a). However, LWP just after predawn differed significantly with stress levels while the LWP at 10.00 am didn't show any significant difference with stress levels (Table 3b). Except the LWP of severely stressed seedlings, well watered and mildly stressed seedlings showed significantly low values when compared to that of mid day measurements. Mid day measurements didn't vary significantly under different moisture stress levels. This revealed that the reduction of transpiration due to stomatal closure resulted in an almost similar LWP in all seedlings during mid day irrespective of the stress level. LWP values just after predawn showed significant differences among stress levels. Well watered seedlings showed higher water potentials due to the presence of sufficient water in leaf tissues. But seedlings of both varieties under both stress levels showed significantly lower LWPs which implied that they were under some degree of moisture stress even at early morning that drives them to conserve water by controlling transpiration.

Table 3a. LWP of CRIC 65 and CRIC 60 measured at 6.00 am and 10.00 am

Variety	6.00 am	10.00 am
CRIC 65	-0.897a	-1.096b
CRIC 60	-0.797a	-1.209b
Sig	ns	ns
CV	20.08	

Table 3b. *LWP under different moisture levels and at different time period*

Treatment	6.00 am	10.00 am
Well watered	-0.496a	-1.189c
Mild Stress	-0.817b	-1.121c
Severe Stress	-1.229c	-1.148c
Sig	***	ns
SE	0.058	
CV	20.08	

*** Significant at $p < 0.0001$

W S Madurapperuma

PROJECT: IMPROVEMENT OF THE PROTOCOL FOR SHELF LIFE IN TENDER COCONUTS

Experiment 08: Improvement of shelf-life of tender king coconut

The protocol for quality preservation of tender king coconuts for a period of one month was obtained by 7 exporters during the year. The experiments were continued to improve the existing protocol for shelf-life improvement of tender king coconut for 1-2 months. Shelf life could be extended up to 36-38 days by vacuum packing of disinfected coconuts (with Captan 0.6 g/L) followed by cold storage (13-15 °C).

A further experiment was conducted to determine the suitable packing material for the vacuum packing. Three materials were tested in this regard.

1. N-LDPE – (Nylon- Low Density Polyethylene)
2. Normal OPP - (Normal oriented Polypropylene)
3. Polyethylene - gauge 300

LDPE is a permeable packing material which has the thickness of 85 μ and the pore size of 70 μ thus facilitating the exchange of gases. However, N-LDPE with the presence of extra nylon layer which acts as a sealing material with 15 μ pores prevents gas exchange from inner to outer. Thus, N-LDPE did not provide a better environment for the vacuum packing of king coconuts. Though these materials were ideal for vacuum packing of non-living specimens, they were not suitable for live specimens like king coconuts. King coconuts respired during storage and released CO₂ which were trapped inside due to the nylon layer with small pores of 15 μ . This gas was tested and confirmed as CO₂. This phenomenon did not take place in polyethylene due to the presence of larger pores of 70 μ . Normal oriented polypropylene couldn't be sealed properly hence were not ideal for packing. Finally, polyethylene was identified as the best material for the vacuum packing of king coconut.

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W P K K Fernando, M Gunawardane*

Experiment 08: Identification of different coconut cultivars for beverage purposes

The objective of this experiment was to identify suitable cultivars that could be used in tender nut industry. Tender nuts (seven and eight months after pollination) of 10 selected cultivars viz. *Dwarf Green (DG)*, *Dwarf Yellow (DY)*, *Dwarf Red (DR)*, *Dwarf Brown (DB)*,

Cameroon Red Dwarf (CRD), King coconut (KC), Bodiri (BD), Murusi (MU), Bothal Thembil (BT) and Juvan (JU) were collected from BE, PRS and Galle area. According to the analysis of sugar profiles, seven-month old nuts of *BD* showed significantly higher sucrose (2-fold, $P < 0.001$) and invert sugar (glucose and fructose; approx. 50%) contents compared to the mean of all cultivars (Fig. 2a, c & e). This resulted in a 50% higher total sugar content in seven-month old nuts of *BD*. Similarly, eight-month old nuts of *BD* contained 3-fold higher sucrose content and about 30% higher invert sugars resulting in an increase of total sugars by 40% compared to the mean of all cultivars (Fig. 2b, d & f). Thus one-fold increase of sucrose content and about 20% decrease of invert sugar content were observed from 7 - 8 month period. *BT* showed the lowest sucrose, invert and total sugar contents out of the tested cultivars. No significant differences were observed among other cultivars with respect to above parameters in both developmental stages.

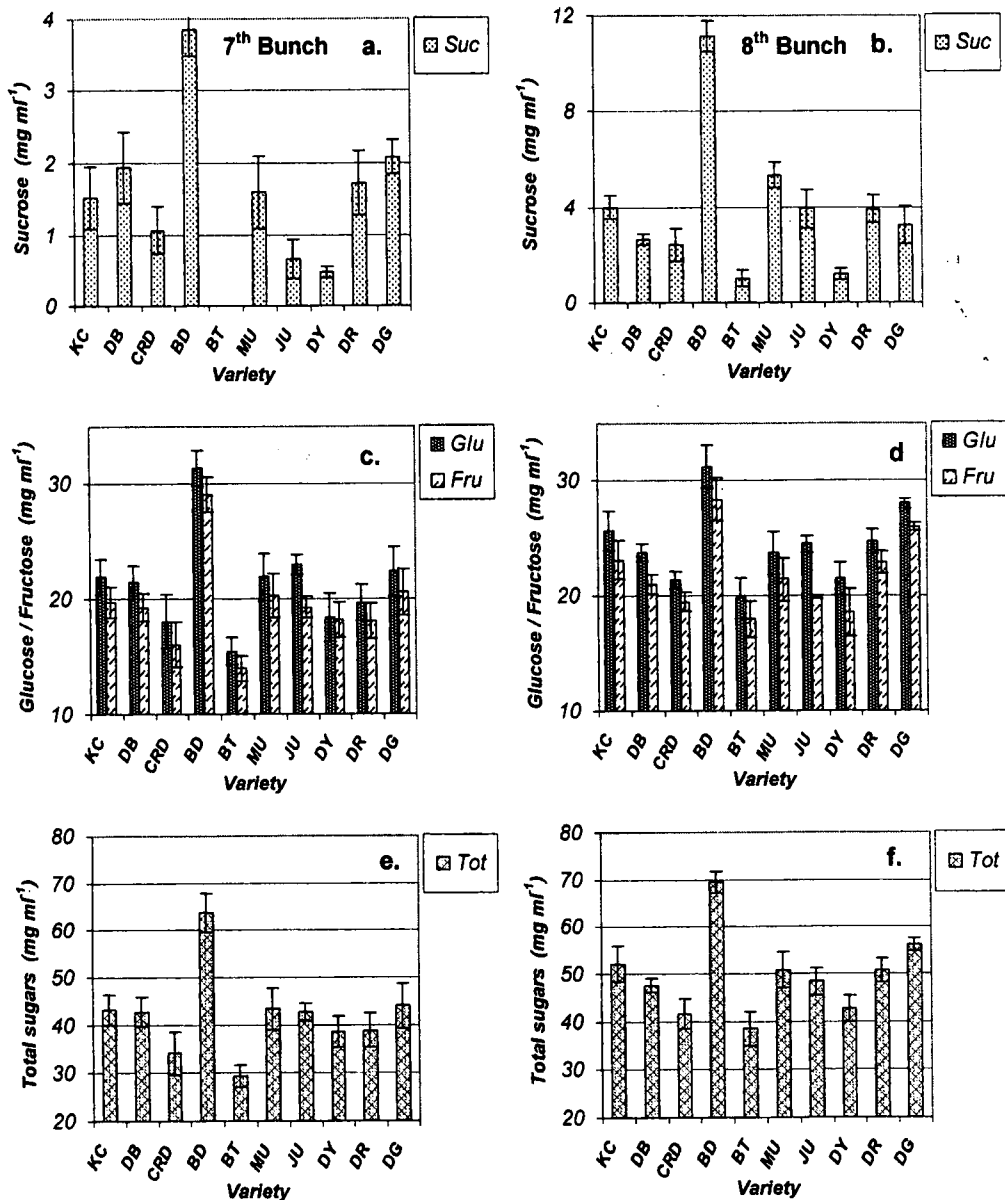
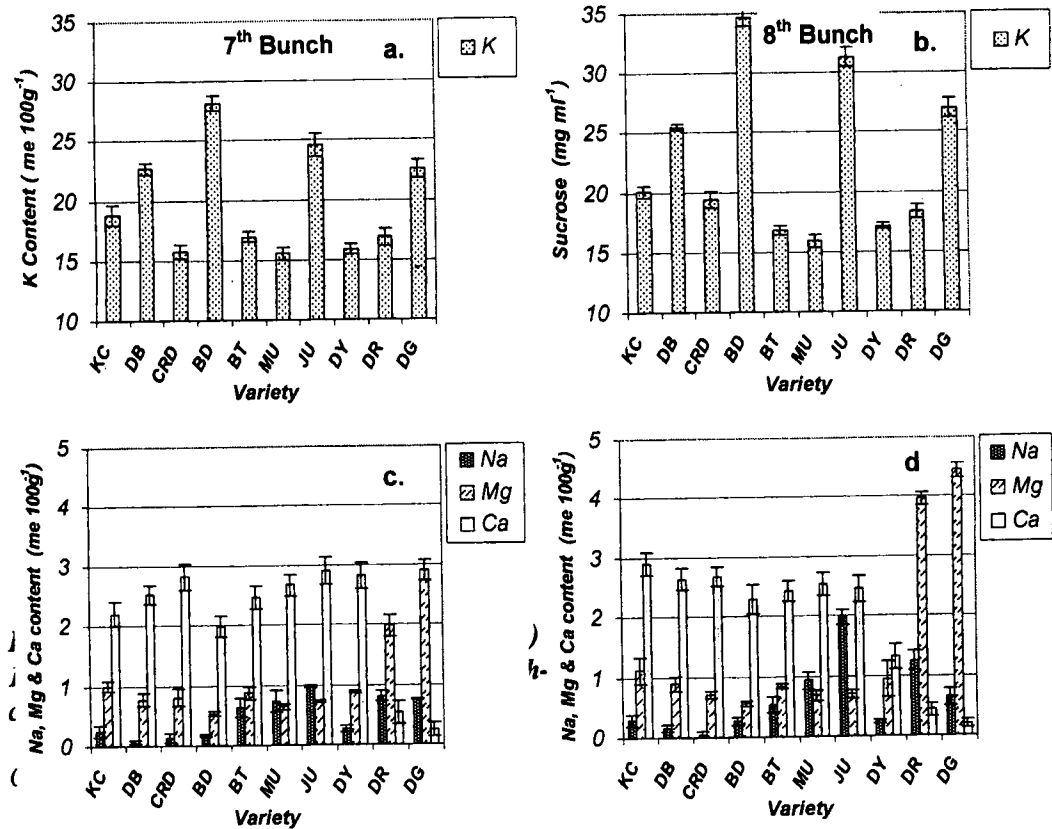


Figure. 2 : (a & b) Sucrose (mg ml^{-1}) (c & d) glucose and fructose (mg ml^{-1}) and (e & f) total sugars (mg ml^{-1}) in nut water of seven and eight month-old nuts respectively in 10 selected coconut cultivars.

BD also contained about 45% and 55% higher K contents respectively in nut water of 7 and 8 month-old nuts compared to the mean of all cultivars (Fig. 3a & b). However, it contained significantly low ($P < 0.01$) Na and average contents of Mg and Ca in both developmental stages (Fig. 3c & d). Cultivars JU, DG and DB also contained higher levels of K in both 7 and 8 month old nuts. Although the Na, Mg and Ca levels of JU and DB were approximately similar to those of the rest, DG showed significantly higher (3-fold) Mg content in both developmental stages. DR also showed an increase of Mg similar to that of DG. Accordingly, BD appeared more suitable as a beverage with higher content of sugars (both sucrose and invert) of which sucrose prominently contributing for its taste. Vitamins of nut water are yet to analyze.



PROJECT: MITE INFESTATION IN COCONUT

Experiment 09: Comparison of biochemical contents of mite-infested and mite free nuts

This is a study on mite-feeding areas (soft tissues under the perianth) of mite-infested nuts and mite-free nuts collected from different areas using selected biochemical parameters i.e. total sugars and polyphenol contents. The objective of this experiment is to identify any biochemical characteristic in the mite feeding area in relation to their vulnerability or tolerance to mite. Varieties with different sensitivities to mite infestation were selected for the preliminary investigation which included *Dwarf Yellow*, *Gon thembili*, (tolerant), *San Ramon* (less sensitive), *Tall* (sensitive) and *Dwarf Red* (very sensitive). Polyphenol analyses are in progress with the assistance of Tea Research Institute, Thalawakelle.

C S Ranasinghe, W P K K Fernando

MULTI DISCIPLINARY PROJECTS
Project Coordinator – C S Ranasinghe, Ph D

THRUST AREA: CROP PRODUCTION

Participating Divisions:

Plant Physiology Division, Crop Protection Division, Soils and Plant Nutrition Division and Agronomy Division

1. GENERAL

Transmission Electron Microscopy (TEM) analysis of Leaf Scorch Decline (LSD), Tapering Disorder (TD) and Coconut Rapid Decline (CRD) affected palms to determine the presence of sub-cellular pathogens and cellular abnormalities is in progress. Although the preliminary images revealed the presence of suspicious phytoplasma and virus-like bodies, it was not shown in the rest of images thus needs verification with further images. There were no significant improvement of nutrient status, specially Zn and Cu, in LSD affected palms even after doubling the concentration of nutrients (macro and micro) and continued application for four consecutive years in three experimental sites, PRS, BE and WE. The data collection was in progress for the determination of the effect of toxins of *Fusarium* spp. in LSD affected palms.

As the study of population dynamics of the burrowing nematode *Radopholus similis* revealed that pruning of roots reduced symptoms of LSD, a study was initiated to assess this effect in 3 different estates affected by LSD. Root pruning of 1/3 of the manure circle (up to a depth of 9") and 1/2 of the circle at 2-, 4- and 6-monthly intervals was conducted and morphological data are being collected. Five different treatments were imposed to investigate the improvement/recovery of LSD, TD and CRD-affected palms. Chemical, physical and biological properties of soil, canopy observations, and yield and root parameters are scheduled to collect during the next year.

PROJECT: STUDIES ON PLANT DISORDERS, LEAF SCORCH DECLINE (LSD), TAPERING DISORDER (TD) AND COCONUT RAPID DECLINE (CRD) OF COCONUT

Experiment 01: Detail anatomical studies on cellular and vascular abnormalities (Plant Physiology Division)

Determination of the presence of sub-cellular pathogens and/or cellular abnormalities of Leaf Scorch Decline (LSD), Tapering Disorder (TD), Coconut Rapid Decline (CRD)-affected palms using Transmission Electron Microscopy (TEM) was the objective of this experiment. Affected palms of mild and moderate stages and apparently healthy palms were selected for the experiment from BE MSG and PRS. Samples from different parts of affected palms i.e tender flower stalk, mid rib (ekel), root tip and trunk were collected, fixed in a buffer solution (3% Glutaraldehyde, 3% Formaldehyde in 0.1 M Phosphate buffer, pH 7.0), stored in ice for 3 days and sent for TEM analysis to Iowa State University USA. Preliminary images revealed the presence of suspicious phytoplasma and virus-like bodies but the next set of images were free from them. Further TEM analysis is yet to conduct.

Experiment 02: Evaluation of the effect of nutrient application on expression of LSD and TD symptoms (Plant Physiology Division)

The objective of this study was to evaluate the effect of leaf spraying of macro and micronutrients on the expression of palm decline symptoms. Previous experiments have revealed that all three types of decline-affected palms were deficient in micro nutrients, especially Zn. Also, spraying was identified as the best method for providing micro nutrients to the palm. Therefore, LSD and TD-affected palms at BE, PRS and WE were treated with nutrient sprays at 3-monthly intervals while monitoring the leaf nutrient status of the 14th frond. Even after two years of nutrient application, the nutrient levels (macro and micro) of decline-affected palms did not increase consistently in all the locations (BE, PRS, WE) and were below the critical levels, irrespective of the severity stages (mild or moderate). Therefore, the nutrient concentration of the spraying solution was doubled.

Results revealed that there was no significant improvement of nutrient status in LSD affected palms even after doubling the concentration of nutrients and continued application for four consecutive years in three experimental sites above. Though some positive treatment effects were observed in some years, results were not consistent throughout the period in all three sites. The percentage of scorching fronds showed reducing trend in the second year of nutrient application but was not consistent over the period. Above change may be due to the compounding effects of meteorological factors mainly rainfall. Although preliminary investigations showed some degree of improvement in nutrient status in LSD affected palms with foliar application of nutrients compared to the methods such as root feeding and trunk feeding, the same trend and consistency could not be observed in large scale applications. The level of absorption of micronutrients, especially Zn and Cu, which were the targeted nutrients in this regard, may not be sufficient when applied as a solution containing full spectrum of nutrients. Hence, it is expected to continue the leaf spraying only with Zn and Cu to test whether the scorching could be arrested.

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Experiment 03: Studies on the association of parasitic nematodes and fungi with Leaf Scorch Decline (LSD) of coconut (Crop Protection Division)

Determination of whether toxins of *Fusarium* spp. are present in the tissues of LSD affected palms (Crop Protection Division)

Previously it has been found that high levels of *Fusarium* spp. are associated with roots of LSD-affected palms. The study was initiated to determine whether the toxins produced by the fungus are present in the tissues of affected palms was repeated to confirm the results. The results are being analyzed.

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P. H. A. P. Siriwardena (CPD) & W.W.N. Fernando (CPD)*

Experiment 04: Determining effect of root pruning in remission of LSD symptoms

In the study of population dynamics of the burrowing nematode *Radopholus similis* it was indicated that pruning of roots reduced symptoms of LSD. Therefore, a study was initiated to assess this effect in 3 different estates affected by LSD. Each of 105, LSD-affected palms was selected at Bandirippuwa estate, Rathmalagara estate and Pottukulama estate. In each estate root pruning was carried out at 2-, 4- and 6-monthly intervals. At each pruning, roots of 1/3 of the manure circle (up to a depth of 9") of 15 palms were pruned while in another 15 palms, ½ of the circle was pruned. Fifteen palms were kept as the control. The total number of leaves and the number of affected leaves of all palms were recorded at the beginning of the experiment. Thereafter, at 4 monthly intervals, the number of newly affected fronds was recorded.

L. C. P. Fernando (CPD), P. H. A. P. Siriwardena (CPD),
& W.W.N. Fernando (CPD)

Experiment 05: Assessment of the efficacy of various treatments on improvement/recovery of LSD, TD and CRD-affected palms (Plant Physiology Division, Soils and Plant Nutrition Division, Crop Protection Division)

Based on the detailed soil map prepared for Makandura Research Station (MRS), six major soil types from 'very suitable' to 'not suitable' for coconut cultivation were identified with their LSC and other soil properties as shown in Table 4.

Table 4: Major soil types, their properties and land suitability classes of different soils available at Makandura Research Station.

Soil Type	Properties
1 (<i>Halpe</i> series)	S2 (Suitable to very suitable) Well drained, deep (>120 cm), Sandy loam, sandy clay loam
2 (<i>Kandetiya</i> series)	S3 (Suitable) Moderately well drained, deep (>100 cm), sandy clay loam to clay loam
3 <i>Kandetiya</i> series (moderately deep phase)	S4 (Moderately suitable) Moderately well drained, moderately deep (70-100 cm), sandy loam to sandy clay loam
4 <i>Makandura</i> series	S4 (Moderately suitable) Imperfectly drained, moderately deep (60-80 cm), sandy loam to sandy clay loam
5 <i>Mahayaya</i> series	NS (Marginally or not suitable) Poorly drained, moderately deep (60-70 cm), Loamy sand to sandy loam
6 <i>Toppuwa</i> series	NS (Not suitable) Poor to very poor drained, moderately deep to shallow, Sandy clay loam, silty clay loam

Out of the six major soil types at MRS, soil types 5 and 6 (*Mahayaya* and *Toppuwa* series) were not suitable for coconut cultivation hence, excluded for the evaluation. The main objective of the experiment is to evaluate the effect of different treatments on the recovery of decline symptoms of palms of three types of disorders. Experiment was in a Randomized

Complete Block design with three disorders (LSD, TD and CRD), Five treatments (T1, T2, T3, T4, and T5; details are given below), two block (B1 covering S2 LSC [*Halpe* series] and B2 covering S3 and S4 LSC [*Kandetiya* and *Makandura* series]) with three palms per plot thus including 90 palms altogether for evaluation.

Treatments:

- T1- Control (no specific treatment but with the basal application of 3 kg of APM and 1 kg of Dolomite per palm year)
- T2 - Charcoal and poultry manure (90 kg of Charcoal and 60 kg of Poultry manure per palm per year; 3:2 ratio)
- T3 - Vermicompost (60 kg per palm per year)
- T4 - Oxytetracycline (5g of OTC / 5 ml of water per palm with two treatment applications a year)
- T5 - Commercial compost (60 kg per palm per year)
- T6 - Irrigation (Application rate)

Treatment application was completed by December 2006 after preliminary data collection. Monitoring of soil chemical and physical properties (Macro and micro nutrients, cation exchange capacity, soil pH, electrical conductivity, organic carbon content, soil compactness, water holding capacity, field capacity, bulk density and soil microbiological parameters) canopy observations (Total number of fronds, number of affected fronds, length of the newly opened frond, length and diameter of the inflorescence prior to opening, girth of the trunk just below the last leaf base and 1 foot below and canopy photographs to monitor the visual changes at the canopy) yield parameters (total number of female flowers, number of set nuts, final yield and fruit components) and root parameters (number of new roots in a volume of one cubic feet at the manure circle) are scheduled for 2007.

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**REPORT OF THE AGRICULTURAL ECONOMICS AND AGRIBUSINESS
MANAGEMENT DIVISION
Head-I M S K Idirisinghe**

1. GENERAL

Agricultural Economics discipline has a key role to play in the development of coconut industry in Sri Lanka in terms of generating “knowledge” against generating “technologies” with regard to most of the other disciplines.

The knowledge on economic feasibility of different recommended technologies in natural science discipline (e.g. fertilizer application, supplementary irrigation, manufacture of new coconut kernel products etc) is important for the sustainable development of the country. The knowledge on economic feasibility of various technologies enables different stakeholders (farmers, entrepreneurs, producers) to arrive at a decision on adopting the technologies recommended by the Coconut Research Institute of Sri Lanka. In regard to policy makers, this knowledge is vital in arriving at more appropriate policy decisions towards resource allocation for the development of the industry as well as economic development of the country.

Considering the importance of socio-economic research, a new research division was established in 01 June 2006. A new building was constructed for the division under CESS assistance and also all the furniture and office equipment were purchased using CESS funds.

Agricultural Economics and Agribusiness Management Division

Vision of the division is to be the centre of excellence in Agricultural Economics and Agribusiness Management research in coconut industry.

Mission of the division is to generate Agricultural Economics and Agribusiness Management knowledge to meet the challenges of the coconut industry.

The mandate of the division is to conduct research, survey and maintain data bases relevant to agricultural economics, agribusiness management, socio- economic and policy issues relevant in coconut industry and also to advice on all matters relating to agricultural Economic, Agribusiness Management, Socio-economic and policy issues to the coconut industry that may arrive from time to time.

2. RESEARCH AND DEVELOPMENT

Establishment of Agricultural Economics and Agribusiness Management Division

A new building was constructed and it was equipped with new furniture, computers and other relevant office aids by utilizing CESS funds.

Progress of the socio-economic research

The national coconut production during the last ten years (1995-2004) varied between 2392 million (minimum in 2002) and 3096 million (maximum in 2000), averaging 2665 million nuts/annum. Coconut production changes due to various reasons despite the static culinary demand (app. 2000 million nuts) and therefore, only the excess nuts would avail for the processing industry, mainly desiccated and coconut oil manufacture.

The DC production is determined by demand and price in the world market. If cost of DC production (COP) exceeds the market price due to high nut price, the DC mills can not sustain. On the other hand, even if the nut prices are amenable for DC miller, the production can not increase beyond the world market share, which is approximately 60,000 MT/year. Coconut oil industry, the other excess nut user in the country therefore, needs to be protected to absorb the excess nuts by means of copra and oil to maintain a reasonable farm gate price for coconut and thereby to safeguard the grower. A recent survey conducted by CRI (2006) revealed that coconut oil mills are not fully operating because of the cost of production of coconut which prevents it from competing with the prices of imported edible oils.

In order to protect the grower, DC miller and oil miller, the state involvement is necessary. This could be achieved by imposing a suitable tariff for imported edible oils and compensating DC millers for every kg of DC produced from the tariff collected. This will make both industries viable while maintaining a reasonable farm gate price for grower irrespective of the changes in production. Because, this gives due consideration for prices of palm oil, DC and other important parameters such as costs of nut, oil and DC production which influence the nut price.

Based on the analysis, a CESS of Rs. 12.00 per kg for importing edible oils is suggested to make the farm gate price of a nut, Rs. 10.34 agreeable for oil miller. In order to check the real effect of this change this increase of CESS is proposed in two stages, first by increasing up to Rs. 6.00 per kg. of imported palm oil and thereafter to Rs 12.00 after three months after analyzing the market situation. If the CIF price of edible oils exceeds US \$ 4.50 per Mt the CESS rate has to be adjusted to keep the market price constant.

Based on COP and buying price of DC by the shipper, DC is still profitable at the farm gate nut price, Rs. 10.32 at the shipper buying price level of DC. Rs. 83.00 and therefore compensation is not required. If the price of nuts exceeds Rs. 10.34, DC manufacturers should be compensated at a rate of Rs. 1.83 per kg. Thereafter, the rates are Rs. 5.16, Rs. 18.78 and Rs. 25.56 per kilogram for the nut prices Rs. 10.76, Rs. 12.46 and Rs. 25.56 respectively.

A case study was conducted in Heenkenda Gramaseva Niladhari (GN) division in Gampaha District to explore the potential for home gardening in semi-urban areas. A household survey was conducted and findings revealed that there is a possibility of converting 14.29% of the net consuming respondents to the self sufficiency state by encouraging the households to grow coconut seedlings. By achieving the optimum space utilization, an additional 13% of the culinary nut requirement can be satisfied. At the moment 44% of the respondents hold self sufficient and it can be increased up to 57%. There is a knowledge gap in proper coconut cultivation technology and accessibility to improved varieties. By filling this gap, a higher yield would be obtained and it will reduce the culinary demand on coconut. This will ultimately save more nuts for industrial purposes. This study

was expanded to an urban settlement belonging to Rathupassara GN division in Gampaha district and the analysis is in progress.

Samurdhi Coconut Development Programme is a collaborative coconut development programme initiated by the Coconut Cultivation Board (CCB) and Samurdhi Authority. A study was conducted to evaluate this program considering the request made by the CCB. This programme has been conducted in almost all the coconut growing areas. However, to find out the success level of this programme, initially, the evaluation part of this programme was carried out in three regional management areas belonging to Anuradhapura, Gampaha and Moneragala districts. Household survey was conducted in those three districts by selecting beneficiaries. According to the results the success rate of the programme, in terms of the existence of seedlings, is greater than 75%. Data analysis is in progress.

The coconut sector plays an important role in regional/provincial GDP in coconut growing areas. There is a gap between the actual requirements of the regional level development plans and the centrally prepared development plans. This is mainly due to the lack of appropriate information for the planning process. At present, to calculate provincial level GDP, national averages are used. Also for cost of production calculations, Department of Census and Statistics uses only the estate sector information neglecting the small holder that contributes more than 75% of the land extent. Therefore, the objectives of this project is to identify the contribution of different cost components to total Cost of Production (COP) of coconut, Desiccated Coconut (DC), coconut oil, coir fiber, and coconut milk, to compute the COP of major coconut products i.e.-DC, copra, coconut oil, coir fiber, coconut milk and to estimate the production levels of major coconut products (i.e. DC, Copra, coir fiber etc.) in coconut triangle, and in other coconut growing areas. This project was initiated and cost of production data of two major coconut products, DC and coconut oil were collected. The collected information revealed that some important cost components have not been considered for the cost of production calculations of these products. Collection of data on cost of production is in progress.

According to the Customs Department information, imports of palm oil are increasing every year. In the year 2005, palm oil import was around 306925.18 MT (CDA Annual Report 2005). There is a very high price difference between palm oil and coconut oil. Coconut oil industry is a heavily protected industry today. According to economic theory, free trade is more beneficial than protection in efficiency terms. Therefore, a study was commenced with the objectives of measuring the magnitude of trade distortions in coconut oil market, to measure the annual welfare loss/gain to the nation taking into account the consumers' gain/loss, producers gain/loss and government gain/loss. To measure these parameters, logistic model building process has been completed. Data collection is in progress.

Often there exists a conflict between economic growth and environmental protection. Today we have to be concerned of sustainable economic growth with environmental protection. World trade is increasingly becoming concerned with quality standards. ISO 9000 is related to product quality whereas ISO 14001 seeks Environmental Management System (EMS) compliance. Thus, ISO 14001 will affect export-oriented industries in future. At the production point, DC industry does not exercise Environmental Management System (EMS) compliance. EMS compliance is required, sooner or later. An average mill discards 12,500 liters of coconut water with 500kg of sugar and 75kg of oil which leads to ground water pollution, bad odour. To correct this problem, it is necessary to apply environment friendly

management systems. By applying proper systems, industry can gain some benefits, while reducing the cost. Therefore, a study was conducted to identify cost and benefits of applying ISO 14001 conditions to DC industry and to propose better system for this industry. Study is in progress.

According to the requests made by the industry, a number of sub-project appraisal works was conducted. Calculating cost of production of virgin coconut oil, cash flow analysis of proposed intercropping and livestock projects in Kurunegala Plantation Ltd, and proposed new Seed Garden Program are some of those projects which we were undertaken during this period.

2. RESEARCH PROJECTS

PROJECT 1: ECONOMIC STUDIES ON POLICY ISSUES

Experiment 1: Determination of Optimum Tariff for Substitute Oil Imports and Compensations for Desiccated Coconut Industry

Objectives of the study were to estimate the cost of production of desiccated coconut (DC), coconut oil and to identify the optimum tariff and surcharge or CESS levels to keep the farm gate price of coconuts at or above Rs. 10.00 per nut

The widely used coefficient for transforming coconut into coconut oil and desiccated coconut is to take 8000 nuts as equivalent to one MT of coconut oil or desiccated coconut. To bring into a playing level in the market (equal chance to compete in the market for both coconut oil and palm oil) oil prices need to be adjusted.

$$\text{Landed cost of palm oil} = \text{CIF value} + \text{duty} + \text{surcharge} + \text{VAT} + \text{CESS} + \text{other charges on clearing}$$

$$\text{Coconut oil price} = (\text{Price of a nut} \times 8000) + \text{Processing cost of coconut oil}$$

At the playing field level,

$$\text{Local CNO price} = \text{Landed cost of palm oil}$$

$$(\text{Price of a nut} \times 8000) + \text{Processing cost of CNO} = \text{CIF value of palm oil} + \text{duty} + \text{surcharge} + \text{VAT} + \text{CESS} + \text{Other charges}$$

At present, landed price of imported oil is lower than the local CNO prices as the COP of CNO is higher because of prevailing market price of copra.

Therefore, to make the playing field level to both parties (CNO millers and substitute oil importers) CNO price and landed price of imported oils need to be made equal. This can be achieved by adopting of following means or their combinations.

a. Changing duty

Already there is a custom duty of 28% on importing edible oils. According to the Customs Department information this is the maximum that can be imposed for an importing commodity. Therefore, the scope to change this duty is limited.

b. Increasing CESS

There is already Rs. 3.00 per kg CESS on importing edible oils. This figure can be adjusted and the collection can be used to build up an utilizable fund to assist key players in the coconut industry. This option therefore, is favored by all means.

c. Increasing surcharge

There is already a 10% surcharge on duty value for importing edible oils. This is also a possible adjustment but since this is calculated as the % to the imported duty, effect of imposing this surcharge is minimal. Therefore, to reach the required level of price in the market, this needs to be adjusted to a very high percentage.

Considering the above facts, it is quite obvious that adjusting the CESS is the best option to control the price of coconut.

Generated outputs and policy guidelines

1. Cost of production of coconut oil and proposed CESS

Cost of Production (COP) was calculated using the data collected from the oil mills and the average COP was calculated by the prevailing average copra price (Rs. 13347.00 per candy - 254 kg). To bring the farm gate price to the level of Rs. 10.00, CESS rate has to be adjusted appropriately to give equal chances to imported edible oil and the local coconut oil in the market. To equate landed price of the palm oil prices to CNO prices, following adjustments are possible for CESS charge (Table 1). These rates have to be revised by considering the prevailing market prices of the coconut oil and CIF prices of the palm oil.

Also when the price of imported edible oil goes up, to keep the market price affordable to the consumers, the CESS rates have to be reduced. It is also necessary to increase the CESS accordingly for palm kernel oil because of the possibility of palm kernel oil becoming a substitute for the cheaper palm oil with the proposed increase in CESS for palm oil.

Table 1: *Proposed change in CESS at different C.I.F. (Colombo) palm oil prices and its corresponding coconut prices*

CIF price of Palm oil (Colombo) US\$	CESS Rs./kg	Calculated nut price (Rs per nut)
450	12	10.34
500	8	10.76
600	6	12.46
650	5	13.31

2. Compensation for DC industry

COP of DC was calculated considering the prevailing market price (Rs. 11.33 per nut). When the farm gate price of a nut is at Rs 10.34, the COP of DC lies around Rs. 82.00 (Table 2). The main contributing factor for COP (excluding raw material) is furnace oil (around 35%). By modifying the boiler from furnace oil into charcoal dryer, about half of the cost can be saved.

Table 2: Proposed compensation for DC millers

Palm oil price c.i.f. (Colombo) (US\$/MT)	Determined nut price after changing tariff (Rs/nut)	COP of DC (Rs/kg) *	Shipper price (Rs/kg)	Compensation (Rs/kg)	Palm oil price c.i.f. (Colombo) (US\$/MT)
			Fine	Medium	
450	10.34	82.02	80	81	1.83
			81	82	0.83
			82	83	-0.17
			83	84	-0.79
500	10.76	85.35	80	81	5.16
			81	82	4.16
			82	83	3.16
			83	84	2.16
600	12.46	98.97	80	81	18.78
			81	82	17.78
			82	83	16.78
			83	84	15.78
650	13.31	105.78	80	81	25.59
			81	82	24.59
			82	83	23.59
			99	100	6.59
			105	106	0.59
			106	107	-0.41

Note: COP was calculated considering the furnace oil boiler

* COP of DC was calculated by deducting the income generated from Shells, pairings and red oil

Coconut oil industry

At present coconut oil industry is nonfunctional due to the high cost of production and availability of cheaper substitute oils in the market. The survey conducted by the CRI in January 2006 revealed that out of 13 coconut oil mills, only 33% of the machines in operation about 3 days a week. It was also observed that these 13 mills have 60 machines in good working condition and they are fully prepared to run these in full capacity if the market improves. The following proposals were made by the oil millers to bring the oil industry into normalcy.

1. Create competitive environment with other edible oils by adjusting the edible oil prices
2. Remove the VAT on coconut oil
3. Introduce quality levels for edible oils in the market
4. State support for improving coconut oil mills
5. Subsidize electricity until the industry become profitable

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Experiment 2. Exploring the Potential for Home Gardening in Semi-urban Areas: A Case Study in Heenkenda Gramaseva Niladhari (GN) division in Gampaha District

The objectives of the study were to identify the actual number of coconut palms that can be grown by land size classes, the constraints these households have been experiencing, willingness to participate in a planting program, to calculate the net coconut producing or consuming status of urban and semi-urban households according to their land size classes and size of household, and to launch a pilot planting program in selected two communities.

Heenkenda Gramaseva Niladhari Division in Wattala Divisional Secretariat was selected to represent a semi-urban locality and 30 households were selected randomly. A household survey was conducted using a pre-prepared questionnaire to gather both qualitative and quantitative data. Graphical and tabular analyses were used to analyze the data. Households with less than one acre were selected and categorized according to the land extent.

The highest percentage of net consumers (85%) was recorded in less than 20 perches category. Self sufficiency increases with the increase in land size class and when the land size class exceeds 100 perches, self-sufficiency is achieved. About 50% of the households belong to less than 20 perches category.

The households that produce excess nuts after satisfying the culinary requirement are considered as net producers. Net producers are observed in each of the land categories except in less than 20 perches category. Around 15% of the consumers in less than 20 perches category are not cultivating coconut and remained as consumers only.

Table 1 shows the producing pattern of coconut in each land size category.

Table 1: *Net producers of coconut in different land size categories*

Land size class	% of Respondents	% of Net Producers
<20 P	52	0
20-50 P	24	33
50-100 P	20	20
>100	4	100

Source: Home garden survey (2006)

In terms of the consumption status, 56% of the semi urban households are net consumers. The average per capita culinary nut consumption per annum was found to be 124. Based on the national average household size of 4.4, the annual culinary nut consumption per household is about 547.

Through this survey, the potential of growing new coconut plants was explored. The gap number of palms in Table 2 shows the potential for cultivating more coconut palms in each land size class.

Table 2: Potential for cultivating coconut in different land size classes

Land Size Class	Observed no. of Palms	Potential no. of Palms	Gap no of palms
<20 Perches	38	78	40
20-50 Perches	73	103	30
50-100 Perches	109	144	35
Total	220	325	105

Source: Home garden survey (2006)

To achieve the self sufficiency status, an average household needs at least 9 palms. If the land is utilized to the optimum level, there is a possibility of converting 28.5% of the net consumers to self sufficient status. The average nuts saved from a household per annum is around 193.

The gap between the total observed number of palms and the potential number of palms shows that there is a possibility of cultivating another 105 palms in the surveyed area.

The majority (91%) of the households consume coconut oil for culinary purposes. About 9% uses both coconut oil as well as other oils (palm oil/vegetable oils) for culinary purposes. Average monthly oil consumption per person is 0.9 bottles (674 ml) and per average household, it is around 4 bottles. Although insignificant, the amount of oil used for lighting oil lamps is also contributed to these figures.

Out of the total number of palms, 63% are at bearing stage, whereas 23% are young palms. The percentage of king coconut palms is 11% is king coconut. Only 8% of the respondents are aware of the variety. About 87% of the respondents cultivated their own seedlings or obtained them from neighbors, relatives while the other 13% obtained the seedlings from the sources such as Govijana Seva Centres. About 22% of the respondents were not aware of a reliable source to obtain seedlings.

The DxT hybrid was found to be the most preferred variety due to factors such as early bearing, high yield and short stature. King coconut had a lesser demand as it has no culinary value.

The constraints in home gardening were the disturbances to the neighbouring houses and high cost of harvesting. Pole pickers are not available and climbers are the source of harvesters. Around 52% of the households use hired labor for harvesting while 35% use family labor and the rest collect the fallen nuts.

Among the respondents, 26% were not aware of proper planting methods and they did not apply any inorganic or organic fertilizer. However, 83% of the respondents apply kitchen waste, ash and plant debris to the palms, which could be considered as a source of organic fertilizer. This shows the potential of using household organic waste as a source of nutrients to coconut palms. The balance nutrients have to be supplemented by means of inorganic fertilizer.

The respondents are in need of relevant technology and good planting material. A few expect fertilizer subsidies as well as a reasonable price for their nuts during crop gluts.

There is a possibility of converting 28.5% of the net consuming respondents to the self sufficiency state by encouraging the households to grow more seedlings. Around 92% of the respondents are willing to participate in a coconut cultivation programme with collaboration of relevant authorities. By achieving the optimum space utilization, an additional 20% of the culinary nut requirement can be satisfied. The self sufficiency level at present is 66% and it can be increased up to 86%.

The knowledge gap for proper coconut cultivation technology and accessibility to improved varieties is very high. By filling this gap, a higher yield could be obtained and it will reduce the culinary demand for coconut. This is ultimately to save more nuts for the industrial purposes.

-P.M.E.K.Pathiraja M.T.N.Fernando, .D.J.N.Subasinghe

Experiment 3: Evaluation of "Samurdhi" coconut cultivation development programme-2005

Samurdhi Coconut Cultivation Development Programme (SCCDP) is a collaborative coconut development programme initiated by Coconut Cultivation Board (CCB) and Samurdhi Development Authority (SDA) in 2004. In its second stage, 100,000 seedlings were distributed among 28,030 Samurdhi beneficiaries in 195 Coconut Development Officer (CDO) regions, island wide in 2005. The land holders of less than 0.5 acre category have been increased by five fold from 1982 to 2002. Thus, there is a need to formulate a special programme for coconut development in 0.5 acre category. With the aim of focusing on low-income category, Samurdhi beneficiaries were selected from 0.5 acre land holders. The objectives of this programme were to enhance the efficiency of small land development and to uplift the living status of low income families through by growing coconuts in their home gardens. This programme was initiated by distributing seedlings and a basal fertilizer mixture at a highly subsidized price. The identification of the target groups and organization of training programmes were carried out by Samurdhi Authority. The systematic planting and proper caring of seedlings was explained to the recipients by CDOs. This study aims to find out the effectiveness of this programme and to make suggestions to improve this programme further.

To achieve the above mentioned objectives, a survey of beneficiary households was conducted. Three Regional Management areas representing three districts on a request made by the CCB namely, Gampaha, Anuradhapura and Moneragala were selected. From each Regional Management area, three CDO Regions were selected. The sample size for a Regional Management area was 120 and 40 households were selected from each CDO range.

SPSS statistical software and MS Excel were used to analyze the data.

In terms of living status, the ratio of expenditure on food to total expenditure is 71% in Moneragala region followed by 68% in Anuradhapura and 57% in Gampaha. It shows the lack of investment opportunities and poor standards of living. The expenditure on coconut as a share of total weekly food expenditure is 2% in Gampaha whereas in Anuradhapura and Moneragala it is 3% and 9% respectively. Therefore, this programme will be benefitted in saving money spent on coconut.

Target group selection was at a satisfactory level regardless of the region except 3% in Gampaha and 1% in Anuradhapura. Fertilizer was received by all except 11% in Gampaha due to poor handling and packing. Technology dissemination through this programme is not satisfactory and it should be revised. The area to be handled by a CDO is very large and therefore, the efficiency and effectiveness of technology transfer mechanism is poor. To address this issue, Samurdhi Development Officers or Gramaseva Niladharis can be trained to transfer technology. The present management of the seedlings is at a satisfactory level in each region. Among the distributed seedlings, 89% exists in the field in Gampaha, 81% in Anuradhapura and 84% in Moneragala. In Anuradhapura and Moneragala, pest and diseases was the major cause of seedling death that contributed to 33% and 45% of the loss. Termite attack was a major problem and people in those regions should be educated on preventing measures. In Gampaha was cattle damage was the major cause of crop loss which contributed to 30% of seedling loss. Drought was another cause for 29% of seedling loss in Moneragala and 27% in Anuradhapura. Therefore, beneficiaries should be educated to protect their seedlings from pest and diseases. Fertilizer application is poor in all the regions. In Gampaha region 43% do not apply fertilizer and in Anuradhapura and Moneragala it is 72% and 66% respectively. The use of kitchen waste and ash as a fertilizer source is popular among 41% in Gampaha region and 20% and 33% in Anuradhapura and Moneragala regions respectively. This can be popularized among beneficiaries as the cost of inorganic fertilizer is high.

It can be concluded that this programme was successful in expanding coconut cultivation as well as assisting Samurdhi beneficiaries to save at least some amount of their expenses. Majority of the respondents requested fertilizer subsidies, seedlings and technology which show their interest towards coconut cultivation. Therefore, the technology dissemination process needs to be revised to improve this programme.

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PROJECT 2: ECONOMIC STUDIES ON COST OF PRODUCTION

Experiment 4: Production and Cost of Production of Coconuts and Major Coconut Products at Provincial Level

The coconut sector plays an important role in regional/provincial GDP in coconut growing areas. There is a gap between the actual requirements of the regional level development plans and the centrally prepared development plans. This is mainly due to the lack of appropriate information for the planning process. At present, to calculate provincial level GDP, national averages are used. Also for cost of production calculations, Department of Census and Statistics uses only the estate sector information neglecting the main coconut extent holder; small holder that contribute to more than 75% land extent. Therefore, the

objectives of this project is to identify the contribution of different cost components to total Cost of Production (COP) of coconut, Desiccated Coconut (DC), coconut oil, coir fiber, and coconut milk, to compute the COP of major coconut products i.e. DC, copra, coconut oil, coir fiber, coconut milk and to estimate the production levels of major coconut products (i.e. DC, Copra, coir fiber etc.) in coconut triangle, and in other coconut growing areas. This project was initiated and cost of production data of two major coconut products, DC and coconut oil were collected. The collected information revealed that some important cost components have not been considered for the cost of production calculations of these products. Collection of data on cost of production is in progress.

Table 1: Financial analysis of manufacturing of DC (modernized mill using furnace oil)

Output	Quantity	Unit Price	Gross Income (Rs/day)
DC (fine grade) (Kg)	4415	117	516555.00
DC (medium grade) (kg)	1035	116	120060.00
Full shells	43607	0.65	28344.55
Pairings (kg dry wt)	1255	66.61	83595.55
Red oil (kg) (200.275 kg/Barrel)	80.11	55	4406.05
Gross return			752961.15
INPUTS			
Nuts	43607	14.17	618007.47
Labour cost for red oil extraction	80.11	2.54	203.47
cost for CI (kg)	2.33	70	163.10
Cost for savlone (0.45 lit)	0.45	700	315.00
Counting & sorting of nuts	325	4	1300.00
Dumping coconuts into cages	264.375	4	1057.50
Wet Section			
De-shelling	43607	180	7849.26
Removal of brown pairing	43607	180	7849.26
Dumping of texta remove kernels into tanks	6	250	1500.00
Transporting of shells			
Dumping shells	4	200	800.00
Removal and drying of pairings	3	200	600.00
Dry Section			
Dryer area	2	267.5	535.00
Packing	4	218	872.00
loading	109	1.83	199.83
Brokerage	636615	1%	6366.15

Output	Quantity	Unit Price	Gross Income (Rs/day)
Electricity	9928.17	per day	9928.17
Telephone and fax	1000	per day	1000.00
Yellow coloured labels	0.25	109	29.25
Registration	3000	185	16.22
Furnace oil	1038.67	40.9	42481.60
maintenance cost			2702.70
Staff			
A manager	11644	1	447.85
Assistant manager	7710	1	296.54
Accountant	8780	1	337.69
Clerks	6364	3	734.31
Cashier	5881	1	226.19
Mechanics	6414	1	246.69
Electrician	6917	1	266.04
Quality controller	5720	1	220.00
Supervisors	6545	3	755.19
Boiler operator	6833	1	262.81
Drivers	5660	4	870.77
Helpers	4249	5	817.12
Insurance			945.95
CESS	5450	2	10900.00
Incentives			
EPF ETF			822.00
Money paid for lending money	462192.3	0.16	202.60
Total cost			722127.72
Gross margin (Rs/day)		30833.43	
Gross margin (Rs/kg)		5.66	
Total processing cost	104120.25		
Processing cost for 8000 nuts	19101.57		

The cost of production of DC is Rs. 132.35 per kg and the benefit cost ratio (BCR) at this prevailing inputs and out put price is 1.04, Which means a DC producer can earn Rs.1.04 by investing one rupee in DC production (excluding income grow by products)

In come grow by-products are shown below (table 2)

Table 2: Income by products

By products	Income (Rs) 8000 nuts	Per nuts
Shells	5200	0.65
Pairing	15336	1.92
Red oil	808	0.10
Total	21344	2.67

Table 3: Financial analysis of DC manufacturing modernized mill - coconut shell based boiler

Output	Quantity	Unit Price	Gross Income (Rs/day)
DC (fine grade) (Kg)	4415	117	516555.00
DC (medium grade) (kg)	1035	116	120060.00
Full shells	43607	0.65	28344.55
Pairings (kg dry wt)	1255	66.61	83595.55
Red oil (kg) (200.275 kg/Barrel)	80.11	55	4406.05
Gross return			752961.15
INPUTS			
Nuts	43607	14.17	617911.19
Labour cost for red oil extraction	80.11	2.54	203.47
cost for CI (kg)	2.33	70	163.10
Cost for savlone (0.45 lit)	0.45	700	315.00
Counting & sorting of nuts	325	4	1300.00
Dumping coconuts into cages	264.375	4	1057.50
Wet Section			
De-shelling	43607	180	7849.26
Removal of brown pairing	43607	180	7849.26
Dumping of texta remove kernels into tanks	6	250	1500.00
Transporting of shells			
Dumping shells	4	200	800.00
Removal and drying of pairings	3	200	600.00
Dry Section			
Dryer area	2	267.5	535.00
Packing	4	218	872.00
loading	109	1.83	199.83

Output	Quantity	Unit Price	Gross Income (Rs/day)
Brokerage	636615	1%	6366.15
Electricity	9928	per day	9928.17
Telephone and fax	1000	per day	1000.00
Yellow coloured labels	0.25	109	29.25
Registration	3000	185	16.22
Coconut shells	16800	0.65	10920.00
maintenance cost			2702.70
Staff			
A manager	11644	1	447.85
Assistant manager	7710	1	296.54
Accountant	8780	1	337.69
Clerks	6364	3	734.31
Cashier	5881	1	226.19
Mechanics	6414	1	246.69
Electrician	6917	1	266.04
Quality controller	5720	1	220.00
Supervisors	6545	3	755.19
Boiler operator	6833	1	262.81
Drivers	5660	4	870.77
Helpers	4249	5	817.12
Insurance			945.95
CESS	5450	2	10900.00
Incentives			
EPF ETF			822.00
Money paid for lending money	462192.3	0.16	202.60
Total cost			690469.84
Gross margin (Rs/day)			62491.31
Gross margin (Rs/kg)			11.47
Total processing cost		72558.64868	

Table 4: Cost and returns of oil manufacturing Rs/MT of oil

Item	Rs/Kg	Unit Price	Number of Units	Total
OUTPUT				
1 MT of oil (Rs /kg)	Rs /kg	150.00	1000.00	150000.00
465 kg of poonac (Rs /kg)	Rs /kg	13.50	465.00	6277.50
177 kg of filter sediments (Rs /kg)	Rs /kg	23.50	177.00	4159.50
Gross Return				160437.00
INPUTS				
(A) Variable costs				
Labour				
Two men each for expeller, cutter, dryer and filter (8md)	Rs/md	450.00	8.00	3600.00
Materials				
Copra (1675 kg of copra is required to extract 1 MT of oil or 6.59 candy)	20527.32	20527.32	6.59	135275.04
Fuel wood for dryer (4.35 cubic yard of wal dara is required to obtain 1 MT of oil)	Rs 600/1cubic yard of wal dara	600.00	4.35	2610.00
Electricity	Rs/unit	18.23	208.40	3799.13
Maintenance cost	Rs/mt	118.21	1.00	118.21
Telephone	Rs/mt	378.25	1.00	378.25
Staff	Rs/mt	2678.22	1.00	2678.22
Transport	Rs/mt	1000.00	1.00	1000.00
Bags	Rs/bag	15.00	10.00	150.00
Watcher	Rs/day	200.00	1.00	200.00
Total variable cost				149808.85
Total cost other than				
(B)				
VAT (15%)		0.00	0.00	0.00
Cost including VAT				149808.85
Total cost (RS/MT of oil)				149808.85
Net return (Rs/MT of oil)				10628.15

Source: Survey of oil millers (1999/2000) & update: Survey of oil millers 2007, March

The cost of production 1kg of coconut oil is Rs.150 (excluding VAT) the processing cost of copra is giving in tables.

Table 5: Processing of copra

Item	Rs/Kg
Coconut price (Rs per nut)	14.17
Processing cost of a Candy of copra (Rs)	948.70
Number of coconuts required per candy of copra	1250.00
Cost of production of candy of copra Rs/candy	18661.20
Number of candies per copra required per MT of CNO	6.59
Cost of copra per Mt of CNO	122977.31
Processing cost of a Mt of CNO (Rs)	4096.81
Cost of a MT of CNO - deducting income from filter sediments and poonack	127074.12
Number of nuts to produce 1 MT of oil	8000.00
Cost for nuts	113360.00
Cost for curing copra and processing of CNO	13714.12
Cost of production of 1 Candy of copra	18661.20
Add 10% margin	1866.12
	20527.32
Price of 1 kg of copra	80.82

The experiment is in progress.

*I M S K Idirisinghe, P M E K Pathiraja,
A W A D R Abeysekara and S D J N Subasinghe*

PROJECT 3: ECONOMIC STUDIES ON WELFARE

Experiment 5: the welfare effects of protecting edible oil imports to Sri Lanka

The objectives of this study are to measure the magnitude of trade distortions in coconut oil market, to measure the annual welfare loss/gain to the nation by taking into account the consumers' gain/loss, producers' gain/loss and government gain/loss. To measure these parameters, logistic model building process has been completed. Data collection is in progress.

P M E K Pathiraja, A W A D R Abeysekara and I M S K Idirisinghe

PROJECT 4: ECONOMIC STUDIES ON FEASIBILITY ANALYSIS

Experiment 6: Cost Benefit Analysis of compliance to ISO 14001 by the DC industry in Sri Lanka

Objectives of this study are to identify the waste minimization opportunities, determine the additional cost to produce a kg of DC due to environmental management system and concomitant additional trade and social benefits and further document the need of research for by-product (coconut water) utilization.

World trade is increasingly becoming concerned with quality standards. ISO 9000 is related to product quality whereas ISO 14001 seeks Environmental Management System (EMS) compliance. Thus, ISO 14001 will affect export-oriented industries in future. At the production point, DC industry does not exercise Environmental Management System (EMS) compliance. EMS compliance is required, sooner or later. An average mill discards 12,500 liters of coconut water with 500kg of sugar and 75kg of oil which leads to ground water pollution, bad odour. To correct this problem, it is necessary to apply environment friendly management systems. By applying proper systems, industry can gain some benefits, while reducing the cost. Therefore, a study was conducted to identify cost and benefits of applying ISO 14001 conditions to DC industry and to propose better system for this industry.

Data collection was commenced and the study is in progress.

I M S K Idirisinghe and S D J N Subasinghe

Experiment 6: Feasibility analysis of sub projects of different organizations

According to the requests made by the industry a number of sub-project appraisal works was conducted. Calculating cost of production of virgin coconut oil, cash flow analysis of proposed intercropping and livestock projects in Kurunegala Plantation Ltd, and proposed new Seed Garden Program were some of these projects that were undertaken during the year.

4. ACKNOWLEDGEMENTS

The assistance and co-operation of the staff of the Agricultural Economics and Agribusiness Management Division in conducting research and development activities are gratefully acknowledged. Special thanks are due to all those who contributed in establishing this new division and who helped in designing and construction work. Also our acknowledgment goes to the Accounts division and supplies unit for their co-operation extended in purchasing the office equipment.

REPORT OF THE TECHNOLOGY TRANSFER DIVISION

Head- P A H Nimal Appuhamy

1. GENERAL

During the year the Technology Transfer Division followed new strategies to disseminate coconut cultivation and processing technologies to stakeholders. Several programmes were implemented to update the technical knowledge of field extension staff of the Coconut Cultivation Board (CCB). Collaborative programmes were also implemented with CCB regional staff to identify the field problems and technology related issues in the sector. A significant achievement was made in educating coconut growers and processors through electronic and print media. Several educational and awareness programmes were conducted for school teachers, students, undergraduates and officials of other institutions about scientific cultivation of coconut. A significant increase in the number of coconut growers who obtained the services under these programmes was observed.

2. OTHER ACTIVITIES

- 2.1. Mrs, Hemamala Fonseka, Assistant Extension Officer, completed her MSc in Agricultural Extension
- 2.2. Mr.J K J P Jayawardene, Assistant Extension Officer, continue his postgraduate studies at the Kerala Agricultural University, India under the ICAR/CARP training programme.

3. ADVISORY AND FARM DEVELOPMENT SERVICES

The Divisional staff provided advisory services to coconut growers and processors who visit the Institute seeking technical assistance for their field problems. Arrangements were also made within the division to attend to the needs of stakeholders with high priority.

3.1 Advisory and Consultancy Activities

Because of growing interest of coconut land owners to improve the productivity of coconut lands, a significant improvement was observed in the number of coconut growers visiting the division to seek advisory assistance was also observed. In addition to purchase of technical literature they are keen to purchase new tools such as VCDs, Flash cards, maps and Interactive Multimedia CDs. Over 200 growers and processors obtained their services during the year.

3.2 Advisory Field Visits

Medium level and large scale coconut growers and plantation companies made several requests for advice and comprehensive development plans after inspecting their plantations. During the year nearly 45 field inspections were made on special requests and reports were submitted with necessary recommendations. Requests for field visits received from coconut

growers for general advice and problems were referred to the respective CCB Regional Managers for their action.

3.3 Technical Advise Through Telephone

Dedicated telephone line connected to the Division was extensively used by stakeholders to obtain technical advice and information. A wide publicity was given on this service available for the benefit of coconut growers.

3.4 Advisory Correspondence

The number of letters received from coconut growers requesting technical advice and information on their field problems was increased significantly and prompt action was taken to provide them with relevant information and literature. The letters received regarding field problems which need the attention of the Coconut Development Officers were referred to the Regional Managers of respective areas for necessary action.

4. EDUCATIONAL PROGRAMMES

The following educational programmes were conducted during the year.

4.1 Educational Programmes for Coconut Growers

- One day educational programme for a group of 30 coconut growers was conducted on 10 January
- An educational programme was conducted for a group of 60 coconut growers from Puttalam on 19 January.
- On the request of CCB Training Centre three educational programmes were conducted for three groups of coconut growers
- Educational programmes were conducted for two groups of coconut growers on 12 July and 12 September respectively.
- A familiarization programme was conducted for Mr. O V R Somasundaram, a large scale coconut grower from Tamil Nadu, India on 11 October.

4.2 Educational Programmes for Officers from Other Organizations

- A full day educational programme was conducted for Superintendents of the Chilaw Plantations Ltd on 20 January.
- One day educational programme was conducted for field officers of coconut estates that belong to Bishop House, Chilaw on 28 April.
- An educational programme was conducted for a group of Air Force officials of the Agro Command Unit 24 April.
- A full day educational programme was conducted for research and extension officials of Department of Agriculture, Bombuwala, on 23 May.
- An educational and familiarization programme was conducted for a group of superintendents from the Namunukula Plantations Company Ltd on 27 July.

- A two day educational programme was conducted for a group of trainees from the Entrepreneur Development and Training Bureau, Ratnapura on 13 and 14 November.
- A special programme was conducted to train village leaders in non traditional coconut growing areas. The village leaders were selected from the Hambantota District and the training sessions were conducted at the CRI sub station at Middeniya. Four day training sessions were conducted for a group of about 40 leaders. During the year under review nine two-day training sessions were conducted at Middeniya substation on 26 and 27 February, 23 and 24 March, 20 and 21 April, 18 and 19 May, 15 and 16 June, 27 and 28 July and 11 and 12 September.

4.3 Educational Programmes for School Children

- During the year educational programmes were conducted for 6400 school children from 53 schools from various parts of the country.
- Necessary guidance and information were provided to 48 students following O/Level and A/Level projects.

4.4 Educational Programmes for Students from Other Educational Institutions

- An educational programme was conducted for a group of diploma students from the agriculture school, Wariyapola on 24 January.
- A full day educational programme was conducted for a group of undergraduates from the Faculty of Agriculture, Rajarata University on 13 February.
- A two day educational programme was conducted to 3rd year undergraduates of the Sabaragamuwa University on 07 and 08 December.
- An educational programme was conducted for a group of students from the Technical College, Kuliypitiya on 27 April.

4.5 One Day Educational Programme Series for Coconut Growers

On the request of coconut growers and land owners the one day educational programme series was conducted successfully. This has become the most popular educational programme among the coconut growers. This programme series has been designed based on the training needs of growers. The series includes seven technical programmes on different subject areas in order to improve the knowledge and skills of coconut growers from planting to harvesting. The details of the seven programmes conducted during the year are as follows.

- The first programme of the series was conducted on 26 May at the Isolated Seed Garden, Ambakelle on *"Replanting and under planting of Coconut"* with the participation of 155 coconut growers.

- The second programme of the series was conducted at Ratmalagara Estate on 23 June on "*Soil and Moisture Conservation Measures and Irrigation for Coconut*" with the participation of 160 coconut growers.
- The third programme was conducted at the Bandirippuwa Estate on 28 July on "*Organic and Inorganic Fertilizer Application for Coconut*" with the participation of 52 coconut growers.
- The fourth programme was conducted at the Walpita Research Station on 25 August on "*Intercropping in Coconut Lands*" with the participation of 135 coconut growers.
- The fifth programme was conducted at the Bandirippuwa Estate on 29 September on "*Coconut Pests and Disease Management*" with the participation of 140 coconut growers.
- The sixth programme was conducted at Ratmalagara Estate on 27 October 2006 on "*Rehabilitation of Low Yielding Coconut*" with the participation of 110 coconut growers.
- The seventh programme was conducted at the Bandirippuwa Estate on 01 December on "*Coconut Estate Management*" with the participation of 106 coconut growers.

At the end of this programme series certificates were awarded to those who participated in all seven programmes.

5. SEMINARS AND FIELD DAYS

- 5.1.1** A seminar and a field demonstration were held on 13 and 14 November for a group of potential entrepreneurs from the Entrepreneurs Development and Training Authority, Ratnapura.
- 5.1.2** A seminar on the "Productivity Increase in Coconut Estates" was conducted at the CRI Head Office for the members of the Coconut Growers Association of Sri Lanka on 29 April. Nearly hundred coconut growers participated.
- 5.1.3** On the request made by Mr. Weerakumara Disanayke, JVP MP for Puttalam District a one day seminar was organized on 19 January for a group of coconut growers from Marawila area.

6. COLABORATIVE TECHNOLOGY TRANSFER PROGRAMMES

6.1 Research and Extension Dialogues

During the year under review, three Research and extension dialogues were conducted with the participation of the field extension staff of CCB and the research staff of CRI on the current issues of the sector. These programmes provide opportunities to discuss current field problems and recommend suitable corrective measures. Further, it helps CRI research personnel to get familiar with field problems and CDOO to update their knowledge on new research findings. During the year, the following research and extension dialogues were conducted.

6.1.1 The first research and extension dialogue was conducted at the In-service Training Centre, Bombuwela on 03 February with the participation of CCB regional extension personnel from Galle, Kalutara, and Gampaha. Nearly 45 officials from both institutions participated in this programme. Major cultivation and management problems of these regions were identified and follow up actions were taken.

6.1.2. Second research and extension dialogue was conducted at the Madamulana Training Centre on 10 March. The regional staff of CCB from Ratnapura, Matara, Hambantota, and Monaragala participated in this programme. Certain area specific issues and technology related problems were identified.

6.1.3 The third research and extension dialogue of the year was conducted at Girithale, Polonnaruwa on 19 December with the CCB Regional field staff from Matale, Polonnaruwa, Anuradhapura, Ampara and Trincomalee. Relevant issues identified were referred for necessary action.

6.2. Crop Clinics in Coconut Growing Areas

Under the accelerated programme of Mahinda Chinthana Crop Clinics were conducted at CRI substations with the participation of research divisions. Crop clinic is a new approach to build direct contacts between the research personnel and the stakeholders. Crop clinics were organized in a way that coconut growers and processors could discuss their field problems directly with the experts in the respective technical areas.

6.2.1 The first crop clinic was held at the Pottukulama Research Station, Pallama for coconut growers and school children in the area on 28 February. About 300 persons participated in the programme.

6.2.2 The second crop clinic was held at Ratmalagara Estate, Madampe on 16 March and about 350 people participated.

6.2.3 The third crop clinic was conducted at the Maduruoya Research Station on 04 April and about 450 people participated in this programme.

6.4. Farmer Field Schools.

Farmer Field School (FFS) is a new technology transfer tool suitable for the small holder sector. The division implemented FFS in various coconut growing areas with the financial assistance from APCC. As a pilot study, FFS programmes were conducted once a month with a group of small coconut holders in Dambadeniya, Chilaw, Alawwa, Aunuradapura, Middeniya, Nikkaweratiya and Galle areas. During the year, 65 programmes of FFS were conducted in the above areas.

7. PUBLICITY AND MASS MEDIA PROGRAMMES

The division implemented several publicity and mass media programmes to create awareness and interest on new technologies among the stakeholders.

7.1. TV and Video Programmes

Video documentaries on coconut products, planting of coconut, under planting and replanting, Control of Black beetle and Plesispa were produced during the year.

7.2. Radio Programmes

7.2.1 During the year the divisional staff participated in three live and four recorded radio programmes.

7.2.2 A weekly radio programme, "Kapruka Pamula", was conducted in collaboration with CCB. Recording of these programmes was done in the field with experienced coconut growers and processors. The objective of this weekly radio programme was to educate coconut growers, processors, students and the general public on coconut cultivation, processing, marketing and consumption. During the year 30 programmes were broadcast over Commercial Service, SLBC on Sundays at 10.30 pm.

7.3. Print Media

A series of weekly newspaper supplement on coconut cultivation and management technologies was published in *Diviamina* in colour. This series became very popular among the readers because of the attractive presentation of information and figures. It was an ideal collecting material for those who are interested in coconut cultivation and processing.

7.4 Improvement of CRI Museum

CRI museum was rearranged by introducing new posters and display boards. Ten colorful light boxes were installed.

7.5 Exhibitions

The division participated in a large number of exhibitions and the stalls were arranged with models, light boxes, posters and live displays to promote the coconut cultivation, management and processing technologies. CRI publications and VCDs were in high demand at these exhibitions. Details of exhibitions participated by the division are given below.

- 7.5.1** The division participated in the agricultural exhibition organized to mark the 10th anniversary of Sabaragamuwa University held from 30 January to 02 February.
- 7.5.2** A very attractive exhibition stall was arranged in collaboration with CCB and CDA at the "Deyata Kirula" Exhibition held at the BMICH from 26 to 29 December. This stall was selected as the best stall in the agricultural sector.
- 7.5.3** On the request made by the Association of Small and Medium Enterprises, Puttalam District, the division participated in the exhibition held from 17 to 19 March at the Hindu Collage, Puttalam.
- 7.5.4** The division participated in an agricultural exhibition held at Horana from 07 to 10 April.
- 7.5.5** An stall was arranged at the exhibition organized by "Prathibaha Kala Kāvaya" at Dankotuwa from 05 – 08 October.
- 7.5.6** The division also participated in the Farmers Day Exhibition conducted at Gannoruwa from 12 to 16 October.
- 7.5.7** An exhibition stall was arranged at the Wayamba Udanaya exhibition at Kurunegala from 18 to 20 October.
- 7.5.8** An exhibition stall was also arranged at the Janapathi Samaja Sathkara Seva held at Thissamaharamaya from 28 to 31 October.
- 7.5.9** The division also participated in the Samurdi Sanwathsarika exhibition held at Dankotuwa from 8 to 10 December.

8. PRINTING AND PUBLICATIONS

During the year under review the printing unit of the division undertook over 150 printing jobs of the division as well as other research and administrative divisions. This includes scheduled publications, letters, survey forms, questionnaires, official forms, circulars and handouts.

8.1 Printing of Annual Report

Three hundred copies of the Annual Report for 2005 were printed in three languages for the submission to the parliament. The Annual Report of the institute for 2005 was also printed in 200 copies.

8.2. Printing of flash cards

Flash card is an innovative educational tool for the benefit of coconut growers and trainees working in the field. Ten flash cards were designed with colour pictures on one side and text on the other side on major recommendations. This pictorial guide enables even small holders to understand the recommended management practices. These are issued as a set of ten cards bund together.

8.3 Printing and Issue of Advisory Bulletin

The following advisory bulletins were reprinted due to high demand and sold at the rate of Rs. 30/=

- Intercropping under coconut – 200 copies
- Under planting, production of high quality planting materials and planting of seedlings. – 200 copies.
- Soil and moisture conservation in coconut lands -200 copies
- Inorganic and organic fertilizer application for coconut – 200 copies.

8.4 Printing of booklets for One-day Educational Programme

As a supportive reading material, a series of booklets were prepared and published in Sinhala on relevant subject areas. Their titles and number of copies printed are given below.

- Replanting, planting of seedlings and management of young plantation. – 200 copies
- Soil moisture conservation in coconut lands – 200. copies
- Use of organic and inorganic fertilizers for coconut – 200 copies
- Intercropping in coconut lands – 250 copies
- Pests and disease control in coconut lands – 200. copies
- Rehabilitation of low yielding coconut lands – 200 copies
- Principles of coconut land management – 200 copies.

8.5 Printing and issue of Coconut Technology Update.

Three issues of Coconut Technology Update were published in three languages in 1000 copies each and circulated among the stakeholders. These issues contain information on new technologies and information on the coconut cultivation and processing sector.

8.6 Reprinting of Advisory Circulars.

Revision of entire series of advisory circulars was completed and handed over for printing in four colours. The new advisory circulars have been categorized into four different groups: A Series – Planting and Management of coconut, B Series – Crop Protection, C Series – Productivity Improvement with intercrops and animal husbandry, D Series – Processing of coconut products. Printing these series will be completed during the first quarter of 2007.

9. PRODUCTION OF AUDIO VISUAL MATERILS

9.1 Production of video documentaries

The production of Interactive Multimedia CD (IMMCD) on coconut cultivation was completed as a collaborative programme with the Audio Visual Center, Gannoruwa. The IMMCD on coconut is a user friendly CD, which provides information in the form of text, tables, photos, graphs and video clips on coconut cultivation and management. Copies of the IMMCD will be available for sale from first quarter of 2007. In addition the following video documentaries were also produced and they are available for sale in VCDs at a subsidized rate of Rs. 100/= each.

- Management of Black Beetle
- Management of Plesispa Beetle in seedlings
- Tissue culture in coconut
- Socio-economic activities in the coconut sector
- Gliricidia cultivation in coconut lands
- Soil and moisture conservation in coconut lands

9.2 Production of digital posters

A large number of digital posters were designed and printed highlighting the new technology transfer tools and services of the Institute.

ANNUAL REPORT OF THE LIBRARY
P D U C Dharmapala, Assistant Librarian

1. GENERAL

The library extended regular services to its clients throughout the year. Information needs were satisfactorily extended to outside clients on request.

2. ACQUISITIONS

2.1 Periodicals

The total number of periodical titles received during the year was thirty two. Eight electronic- version periodical titles were received on subscription and the others were received either on complimentary or exchange basis. The full allocation for the books and periodicals used to renew the subscription renewal.

3. SERVICES

3.1 Literature Searches

In addition to the quick reference queries made by the staff 18 literature searches were made on the coconut databases to cater to the information needs of the researchers. Of these searches were made on behalf of the CRI staff while 06 were made for outsiders.

3.2 External Services

Resource sharing activities were continued satisfactorily with other AGRINET libraries throughout the year.

Twenty three people visited the library during the year for information purposes.

4 Meetings & Workshops

Mrs P D U C Dharmapla (Assistant Librarian) attended four AGRINET Meetings at the Council for Agricultural Research Policy.

Mrs P D U C Dharmapla (Assistant Librarian) attended Conference on Building Digital Libraries at the Galleface Hotel

REPORT OF THE ESTATE MANAGEMENT DIVISION
Manager (Estates) -N.P.K Liyanage (B Sc.Agric)

1. GENERAL

The four Genetic Resource Centers and six research subs stations that come under the Estates Management Division were maintained satisfactorily with the continuation of self finance basis. Highlight of the year was the development of newly opened subs station at Middeniya to serve coconut growers in the Southern Province. Among other significant events are: completion of drip irrigation facilities in 70 acres at Ambakelle Genetic resource Center (AGRC) continuation of the development of Pallama Genetic Resource Center for mass production of CRISL98, improvement of Makandura Genetic Resource Centre by planting intercrops, grasses and continuation of multi disciplinary research programmes on soil improving fertility and coconut palm decline syndromes , production of 12.8 million seed nuts, excavation of two ponds for rain water harvesting at the Bandirippuwa Main Research Centre, two ponds at Pallama genetic Resource Center, two ponds at Poththukkulama Research Centre and expansion of livestock production in all Research Centers and Genetic Resource Centers. Two trainings were given to field staff members on live-stock production and new agricultural technology. Labourers who were engaged in livestock activities were also trained with the assistance of Provincial Director's office of Animal production and Health. Three field days were conducted in Maduruoya, Poththukkulama and Rathmalagara centers for the coconut grower and school children under the Mahinda Chinthana program. The overall income from the estates was approximately Rs.61.5 million. Increased yield and selection of seed nut by 54.4% and 39.5% respectively compared to the previous year contributed fort the increased income. The average cost of production (COP) and net sale average (NSA) of all centers were 7.89 and 9.28 respectively.

Among the development programs, continuation of demonstration plots at Pallama, Ambakelle, Poththukkulama and Makandura Research Centers to exhibit recommended field practices, removal of weak and dud palms, planting of high valued timber trees at Bandirippuwa and Poththukkulama Research Centers on areas unsuitable for coconut, continuation of curd and yoghurt production in Bandirippuwa, Rathmalagara, Makandura and Ambakelle centers, continuation of a nursery for producing different colour forms of dwarf coconut along with high yielding coconut cultivars in Makandura, production of calves through Artificial insemination, and expansion of pasture are other noteworthy events of the year. Division extended its facilities to conduct one day training programmes in its Research Centers and Genetic resource Centers organized by the Technology Transfer Division.

2. Performance of individual units

2.1. Ambakelle Genetic Resource Centre (AGRC): Pallama

Superintendent	:	Mr. W.M. Upali Rathnayake
Disriect	:	Puttlam
Agro climatic Zone	:	Intermediate Zone
Extent	:	456.20 ha

The drip irrigation facility which was established wit the assistance of CESS funds in order to increase the production of CRIC65 commissioned this year. Irrigation was stared for

the field no.9, 10 and part of 11Aan area of 75 acres in to diverse the tall field for the purpose of increasing hybrid field, 350 dwarf green were established.

The total production of nuts during the period from October 2005 to September 2006 was 1.53 million, and it is a 45% increase compared to corresponding period of the previous year. The total number of seed nuts issued was 969694 and it is a 68%and 13.4% increase compared to the previous year when as selection percentage in 2005 was 54.6%. The well distributed rainfall during the year 2005 contributed mainly for the increased yield and selection of seed nuts. Rain fall during the year 2006 was 1752 mm up to the end of September.

General maintenance of the seed garden was satisfactory during the year. Annual application of fertilizer was attended by covering all palms of the estate making advantage of both Yala and Maha rains. Three thousand palms were fertilized with organic manure. Preparation of 500 husk pits of the size of 8' x 4' x 4' were completed. Weeding, mulching and other cultural practices were duly attended. Selected dud and weak palms were removed in the plantation after careful selection with the assistance of Genetics and plant Breeding Division.

The available buffaloes were maintained as extensive system for grassing and thereby it helped to weed control. Production of curd and new born buffalo calves contributed to the additional income. It has supplied 19 animals to other CRI estates. Live weight of them was 1515kg. The total income both curd and live weight sales was Rs 614294.00 and net profit was Rs.231230.00.

The main income sources are sale of coconut (Seed nut and selected nut), coconut seedlings and other sundries. They are respectively Rs.17118927.00, 790370.99 and 66205.00. Total income of Ambakelle Genetic resource Centre was Rs.18589696.00. Cost of production (COP) and net sale average (NSA) for 1000 nuts were Rs. 8184.98 and Rs. 11116.87 respectively.

2.2. Bandirippuwa Main Research Center (BMRC)-Lunuwila

Superintendent	:	Mr. G.B.A.Wijesekara
Disrict	:	Puttlam
Agro climatic Zone	:	Wet Intermediate Zone
Extent	:	148.1 ha

The total yield received was 803730 and it is an increase of 115.7% yield when compared to year 2004. The main reason cause to this yield increase was the well distributed rain fall received in the year 2005. Also the rain fall received up to the end of September indicates an increase of total amount (1757.1mm) and number of wet days (126 wet days) by 37% and 46% respectively when compared to the corresponding period of the last year.

Application of fertilizer was completed. Weeding mulching and other cultural practices were duly attended. Two ponds were excavated to harvest the rain water fro the purpose of moisture conservation and to use of buffalo's wallowing. The selected weak palms were removed to get a uniform plantation. Road system within the estate was renovated.

Livestock project, consisting 112 cattle and 18 buffaloes was maintained successfully. The production of curd and yoghurt was continued. Staff members and animal keeping labourers were trained on livestock production with the help of Department of Animal Production and Health. Planting of gliricidia as fodder to feed the animal during dry seasons was commenced in a new block.

The total income received from the sale of coconut, copra and other estate produces as follows;

Coconut	= Rs. 6394185.00
Copra	= Rs. 231004.00
Milk, treacle, fruits, vegetable & timber	= Rs. 1546806.00
Total	= Rs. 8171995.00

When compare the coconut income in this year wit the last year it was an increase of 59% and for copra it was 195% increase. Income from other sources has been improved by 21%. Cost of production (COP) for 1000 nuts was Rs. 7770.00 and Net sale Average (NSA): for 1000 nuts was Rs. 8240.00. This shows a profit of cent 47. Although income was improved from coconut, profit was affected by increase labour and input cost.

2.3. Dunkannawa Research Centre (DRC) - Thabbowa, Naththandiya

Officer in Charge	:	Mr. Newton Gamage
Disrict	:	Puttlam
Agro climatic Zone	:	Intermediate Dry Zone
Extent	:	10.4 ha

This research center has been started in 2001 by acquiring from Coconut development Authority on lease basis. This is on development stage with the establishment of new variety called T x SR (CRISL 98) it has 974 four years old seedlings and old stand of 324 palms of tall variety. It has produced 20825 nuts from old plantation and it is an increase of 64% compared to last year.

A herd of cattle (ten animals) was introduced to this estate in order to increase the income level.

The total rain fall was 1927.1mm and 107 wet days up to the October which showed an increase of 59% & 33% respectively when compared to the corresponding period of the last year. The income from coconut and sundries were Rs.182457.00 and 568650.00 respectively. Sale of coconut seedlings has contributed for the sundry income. Coconut income has been improved by 68% compared to last year.

Cost of production (COP) for 1000 nuts was Rs. 4930.00 and Net Sale Average (NSA): for 1000 nuts was Rs. 9440.00

The existing Cinnamon fields as an intercrop was continued wit new plants being filled for vacancies. One harvest was obtained from the available field. Decision was taken to start coir retting research station by Coconut Development Authority with the assistance of Industrial Technology Institute. A part of the land was allocated for this purpose.

2.4. Maduruoya Genetic Resource Center (MOGRC)-Bogaswewa, Kashyapapura

Acting Superintendent	:	Mr. W.A.Hareld Upali
Disrict	:	Polonnaruwa
Agro climatic Zone	:	Dry Zone
Extent	:	85 ha

This seed garden maintained to supply seed nuts to CCB nurseries in the dry zone. The total yield received was 520060 nuts and it was a 6.5% increase compared to previous year. Effect of drought to this estate has been avoided by having a surface irrigation system. It supplied 276377 seed nuts and it was 4% decrease compared to the previous year. Total rainfall received was 1831.5mm and 50 wet days up to the October which registered an increase by 188% and 104% respectively when compared to the corresponding period of last year.

Income:

Coconut	=	Rs.	4,859,520.00
Sundry	=	Rs.	514,276.00
Total	=	Rs.	5,373,796.0

Cost of production (COP) for 1000 nuts was Rs. 8154.00 and Net Sale Average (NSA): for 1000 nuts was Rs. 10889.85 00. This has recorded a Rs. 2.73 profit margin.

2.5. Makandura Genetic Resource Center (MGRC)-Makandura, Gonawila

Superintendent	:	Mr. A.N.Eknaligoda
Disrict	:	Kurunagala
Agro climatic Zone	:	Wet Intermediate
Extent	:	58.20 ha

The total yield of this estate was 577,713 nuts and it was a 163% increase in yield when compared to year 2005. This estate was under Board of Investment in the year 2004 and a drop of yield experienced in 2005 due to drought condition and non application of fertilizer during that period. The rain fall during the year was 1132 mm and wet days were 68 days.

A remarkable improvement has shown this year with regard to the coconut yield after the development activities carried out in the year 2005. The nut per palm yield was 107 which were the highest among all the estates.

With regard to livestock production, this center maintained 110 cattle and 8 buffaloes for breeding purposes and milk production. All the female cattle were artificially inseminated to produce hybrid calves. Cattle shed was renovated to accommodate animals to the vacant patches created by uprooting palms were utilized to establish improved grasses and to graze animals.

A commercial coconut nursery was started specially to produce dwarf colour forms of coconut to cater for ornamental palm requirements. The produced colour forms were Yellow

dwarf, Red dwarf, Brazilian dwarf, Cameroon Red dwarf, King coconuts. This nursery helped to increase the income level of the centre.

In one of the coconut field 100 Kolikkutu, 25 Ambun, 100 Seeni kelel, 75 Rambutan, 100 Papaw and 30 Lime plants were established as intercrops. A demonstration block was established to show the agronomic practices of coconut and some rare fruit planted in the same block.

Total income received from different activities was as follows;

Income:

Coconut	=	Rs.4, 742,165.00
Copra	=	Rs.81, 037.00
Milk	=	Rs.221, 538.00
Banana	=	Rs.47, 180.00
Nursery	=	Rs.21, 280.00
Sale of cattle	=	Rs.203, 340.00
Sundry	=	Rs.164, 250.00
Total	=	Rs.5, 480,790.00

Cost of production (COP) for 1000 nuts was Rs. 3610.00 and Net Sale Average (NSA): for 1000 nuts was Rs. 8,960.00. This has recorded a Rs. 5.35 profit margin per nut..

2.6. Pallama Genetic Resource Center (PGRC) Pallama

Officer In Charge	:	Mr. A.Thilakarathna
District	:	Puttlam
Agro climatic Zone	:	Dry Zone
Extent	:	252 ha

This estate is in development stages as a seed garden for the mass CRISL 98 production of seed nuts. It consists of mature and immature plantations. From the old mature plantation it was producing 512431 nuts including 16200 seed nuts which collected from selected plus palms. Maintenance of under plantation was done successfully and infilling was done for the existing vacancies. Agronomic practices such as fertilizing, weeding, and mulching have successfully completed and new fence has been established for a distance of 61 fathoms. Tying of hara has been started for a hybridization program of the Genetic and Plant Breeding Division. A nursery was started for germinating the seeds from selected palms and self pollinating palms.

The total rain fall was 1826.1 mm and 99 wet days up to the end of September which registered an increase of rainfall by 146% and increase of wet days by 92% when compared to the corresponding period of the last year.

Few cattle (14) and buffaloes (11) were maintained as a pilot project as it was difficult to rear animals a large scale due to young plantations. Incomes of 4,905,268.44 and 349,926.00 have been received by sale of coconut and sundries.

Cost of production (COP) for 1000 nuts was Rs. 11040.07 and Net Sale Average (NSA): for 1000 nuts was Rs. 9572.54. This has recorded a loss of Rs. 1470.00 per 1000 nuts.

2.7. Poththukulama Research Station (PRS) - Pallama

Officer in Charge	:	Mr. D.L.I.Neththasinghe
District	:	Puttlam
Agro climatic Zone	:	Intermediate Dry Zone
Extent	:	81.73 ha

The coconut production at PRS was 838562 nuts and it was a 30% increased compared to the previous year yields. This estate is used only for research activities and a collection of dwarf varieties maintained in separate block. Routine activities were continued in this centre successfully. All the palms of the estate have been mulched.

Goats and cattle were maintained during the year. Goat project was conducted by the Agronomy Division and estate staff assisted for these activities. PRS was conducting cattle fattening program collecting male animals from CRI estates. 75 goats, 65 cattle and 4 buffaloes were maintained in this year.

Total rainfall received and number of wet days was 1694mm 77 days respectively up to the end of September. This registered an increase of rainfall by 61% and 35% of wet days compared to the corresponding period of the last year.

Income:

Coconut & copra	=	Rs.7, 502,685.83
Sale of cattle	=	Rs.652, 893.40
Sundry	=	Rs.1, 485.00
Total	=	Rs.8, 157,064.23

Cost of production (COP) for 1000 nuts was Rs. 7437.70 and Net Sale Average (NSA): for 1000 nuts was Rs. 8692.23. This has recorded a profit of Rs. 1254.53 per 1000 nuts.

2.8. Rathmalagara Research Station (RRS)- Panirendawa

Officer in Charge	:	Mr. T.M.Keerthirathne
District	:	Puttlam
Agro climatic Zone	:	Intermediate Dry Zone
Extent	:	110.48 ha

Rathmalagara gave an annual crop of 755202 nuts for the period under review in the year 2006 and it is a 25% increase of yield, the reasons for the increase are good of rainfall and maintaining of agronomic practices in order during the previous year. Out of the above nut production 17300 seed nuts have been issued which were separately collected from plus palms.

Total rainfall received was 1666mm and 126 wet days up to the end of September which registered 17% and 57.5% increase respectively.

A cattle project was carried out in this estate and it maintained 62 animals. This contributed to earn an income of Rs. 256140.53 by selling milk products and live animals.

A commercial coconut nursery also maintained successfully and it has contributed an income of Rs. 441120.00 by selling of 14704 seedlings. The income from coconut and copra was Rs. 6622825.51. Including sundry income of 629582.30 it has recorded a total income of Rs. 7950016.34.

Cost of Production (COP): for 1000 nuts were Rs. 8500.00 and Net Sale Average (NSA): for 1000 nuts were 8780.00. This has recorded a mere profit of Rs. 280.00 for 1000 nuts

2.9. Walpita Research Center (WRC)-Walpita

Officer in Charge	:	Mr. Nimal Hemasiri
District	:	Gampaha
Agro climatic Zone	:	Wet Intermediate
Extent	:	17.8 ha

This research station is maintained specifically for the demonstration purpose of intercrops that are planted in coconut plantations. All the intercrops suitable for intermediate conditions have been grown in this center. One day training program was organized by the Technology Transfer Division with the assistance of estate management Division in this center utilizing its resources.

The existing coconut stand is 57 years old and yield is now in declining trend. It is expected to uproot 300 senile trees and start replanting 10 acre extent in next year.

The yield recorded in 2006 was 131812 nuts and it was a 30% increase when compared to previous year.

The total rainfall was 2597mm and 100 wet days up to the end of September which indicate an increase by 55% and 33% respectively when compared to the corresponding period of the last year.

Livestock (5 cows) were maintained to collect cow dung and weed control process initially and later to earn an income from production.

A remarkable income has been achieved from seedling and intercrops in this center and total income was as follows. Further income could be achieved from intercrops if the market of pepper was not dropped.

Income:

Coconut	= Rs. 1425198.68
Seedlings	= Rs. 89070.00
Fruit & spices	= Rs. 132574.31
Other	= Rs. 154323.00
Total	= Rs. 1801166.49

Cost of Production (COP): for 1000 nuts were Rs. 10580.00 and Net Sale Average (NSA): for 1000 nuts were 10810.00. This has recorded a mere profit of Rs. 230.00 for 1000 nuts

2.10. Middeniya Research Station (MRS)-Middeniya

Land clearing this year completed by uprooting all the unwanted mango trees (290 trees). Planting of 1040 seedlings was completed for three different research trials. Nursery was started bedding 15500 seed nuts to cater for demonstration purposes.

Construction of OIC quarters and circuit bungalow were started. Road structure around and within the estate was cut. A deep well was excavated to have a permanent water supply building of the pump house was completed in order to fix the water pump. The construction of the water storage tank (Ferro cement type) having the capacity of 100000liters was started. Construction of medium size tank for rain water harvesting purpose was started with the assistance of Irrigation department. Vehicle requirement of the estate was fulfilled by purchasing four wheel tractors with a trailer, two wheel tractors with a trailer, water bowser and double cab.

Training program which was started last year was continued this year also. Under these programs 162 village level officers (Trainers) were trained on theoretical and practical aspects of coconut plantation. Three farmer field schools were conducted in Galle, Suriyawewa and Middeniya with the coordination of the station. The total expenditure incurred during this year was Rs.17537571.00.

REPORT OF THE ADMINISTRATION DIVISION
Deputy Director (Administration & Finance) – E P Gunapala
A.P.F.A., B. COM (SP), Diploma in Accountancy

1. ESTABLISHMENT UNIT

The unit continued to assist Research Divisions in routine administrative & financial matters and related affairs including maintenance work.

2. CADRE

The staff position of the Coconut Research Institute at the end of December 2006 is given in table 1.

Table 1 : Staff position as at 31/12/2006

Grade	Upgraded	Sp C1	C1 I	C1 II	C1 III	C1 IV	Total
Executive	02	00	10	10	24	40	86
Technical	00	34	10	10	-	-	54
Intermediate	00	05	01	00	-	-	06
Clerical & Allied	00	22	04	04	-	-	30
Operative	00	26	09	07	-	-	42
Driver	00	19	04	06	-	-	29
Minor	00	36	16	14	-	-	66
Watcher	11	00	00	00	-	-	11
Grand Total	13	142	54	51	24	40	324

3. WELFARE

Welfare facilities extended towards the employees from the Board were continued. Financial assistance extended to the employees is given below:

3.1 Financial Aid

Provident Fund Loans: Granted for 85 employees, amounting to Rs.29, 647,000.00

Distress Loans: Granted for 40 employees amounting to Rs.3, 097,903.00

Transport Loans: Granted for 23 employees amounting to Rs.1, 119,125.00

Refrigerator Loans: Granted for 01 employee amounting to Rs.12, 000.00

Loan Relief to Indebtedness**Loans:**

Granted for 01 employees amounting to Rs.7, 500.00

Medical Aid:

Rs.2, 929,410.00 was reimbursed by the Medical Aid Scheme during the year 2006, and an amount of Rs.547, 776.00 was distributed to 317 Savings Accounts of Members.

The following medical clinics were conducted during the year 2005

- Dental Clinic
- Blood Donation Programme
- Medical Check up for members & their family conducted by Asiri Hospitals (Pvt.) Ltd and Sri Lanka Diabetic Centre.
- Check the Blood Sugar of members of Medical Aid Scheme

3.2 Other facilities to employees

- (a) Financial assistance was also granted to the Multi-purpose Co-operative Society, Art Circle, Day Care Centre, Seva Vanitha Movement, Death Donation Society and the Recreation Club during the year 2006.

STAFF MATTERS

4. APPOINTMENTS

No appointments were given during the year 2006.

5. RESIGNATIONS, RETIREMENTS, VACATION OF POSTS & TERMINATIONS OF SERVICES & DEATHS

The details are given in Table 2:

Table 2.

Name	Designation	Division/Unit	Date
Resignations:			
Mr. K W L K Weerasinghe	Research Officer	Crop Protection Division	03.01.06
Mr. A A D N Athauda	Senior Clerk/Typist	Agronomy Division	11.05.06
Mrs. K A P Chandani	Senior Clerk/Typist	Technology Transfer Division	17.07.06
Dr. M T N Fernando	Principal Research Officer	Agronomy Division	18.08.06
Mrs. S. M Mallawarachchi	Research Officer	Coconut Processing Research Division	01.10.06
Miss. H M Nadeeja	Assistant Manager(IS)	Establishment Unit	01.10.06
Mr. H G Wasantha	Technical Assistant	Crop Protection Division	01.11.06

Name	Designation	Division/Unit	Date
Resignations:			
Mr. M A S Fernando	Senior Lab/Field Attendant	Engineering Unit	15.02.06
Mrs. C Munasinghe	Senior Clerk	Estates Management Division	01.05.06
Mr. W Wipulasena	Watcher	Estates Management Division	10.06.06
Mr. S A D Richard	Accounts Clerk	Accounts Unit	20.10.06
Mr. W Sirisena	Senior Lab/Field Attendant	Estates Management Division	18.12.06
Deaths:			
Mr H M Thilakaratne	Senior Electrical Helper	Engineering Unit	15.06.06
Vacated of Post			
Dr C K Bandaranayaka	Senior Research Officer	Genetics & Plant Breeding Division	09.11.06
Mr. N A K de Silva	Research Officer	Agronomy Division	28.12.06

6. PROMOTIONS

6.1 PROMOTIONS IN NON-EXECUTIVE GRADES

Following Internal Promotions in Non-Executive Grades were implemented during the year 2006, as shown in Table 3. The effective date of these promotions was 01/01/2006.

Table 3. Promotions in Non-Executive Grades during the year 2006

Name	Designation	Division/Unit
CLASS 1 TO SPECIAL CLASS		
Technical Grade		
Mr. P H P Roshan de Silva	Senior Technical Officer	Crop Protection Division
Clerical & Allied Grade		
Mr. M A D M F Appuhamy	Senior Clerk/Typist	Establishment Unit
Mr. W A L R Fernando	Senior Clerk/Typist	Estates Management Division
Operative Grade		
Mr. K R E M Fernando	Senior Lab/Field Assistant	Soils & Plant Nutrition Division
Mr. R A Swarnathilaka	Senior Lab/Field Assistant	Agronomy Division
Drivers Grade		
Mr. J Amarasinghe	Senior Driver	Establishment Unit
Minor Grade		
Mr. M S Abeytissa	Senior Office Attendant	Estates Management Division
Mr. H Kapila Prasanna	Senior Lab/Field Attendant	Tissue Culture Division
Mr. J H Ubhayaratne	Senior Lab/Field Attendant	Biometry
Mr. W Wimalasiri	Senior Lab/Field Attendant	Soils & Plant Nutrition Division

Mr. R M N Sandasiri	Senior Lab/Field Attendant	Tissue Culture Division
Mr. N A W Jayasiri	Senior Lab/Field Attendant	Technology Transfer Division
CLASS II TO CLASS I		
Technical Grade		
Mr. R B Attanayaka	Technical Officer	Genetics & Plant Breeding Division
Mr. S A S Chandrasiri	Technical Officer	Genetics & Plant Breeding Division
Clerical Grade		
Mr. H M Podirathne	Clerk/Clerk	Estates Management Division
Mr. D M Jayawardena	Clerk/Clerk	Estates Management Division
Drivers Grade		
Mr. P G P S Karunaratne	Driver	Establishment Unit
Mr. I P K P Perera	Driver	Establishment Unit
Minor Grade		
Mr. N B R Bandara	Guest House Keeper	Establishment Unit
Mr. W . A Hemawardena	Lab/Field Attendant	Agronomy Division
Mr. R P Newil	Office Attendant	Internal Audit Unit
Mr. W A S Jayathilaka	Office Attendant	Coconut Processing Research Division

6.2 PROMOTIONS IN EXECUTIVE GRADES

Following Promotions in Executive Grades were implemented during the year 2006, as shown in Table 4 & 5.

Table 4. Promotions in Executive Grades during the year 2006

Executive Grade Class II to Class I

Name	Designation	Division	Effective Date
Dr. A A F L K Perera	Principal Research Officer	Genetics & Plant Breeding Division	03.08.2005

Table 5.

Executive Grade Class III to Class II

Name	Designation	Division	Effective Date
Dr. H T R Wijesekara	Senior Research Officer	Crop Protection Division	29.08.2005
Dr. S A C N Perera	Senior Research Officer	Genetics & Plant Breeding Division	14.09.2005

7. TRANSFERS

1. Mr. J.A.R.Reginold, Senior Clerk from Genetics Resource Center Pallama to Genetics Resource Center Ambakelle – On January 01
2. Mr. W.W.A.P.R Fernando, Supervisor from Genetics Resource Center Ambakelle to Genetics Resource Center Pallama – On January 01
3. Mr. G.B.A.Wijesekara, Superintendent from Bandirippuwa Research Station to Rathmalagara Research Centre – On January 27
4. Mr. I.A.N.Hemasiri, Superintendent from Walpita Research Center to Bandirippuwa Research Station – On January 26
5. Mr. H.M.Podiratne, Clerk/Typist from Genetics Resource Center Ambakelle to Genetics Resource Center Pallama – On January 16
6. Mrs. P.J.M.Fernando, Lab & Field Attendant from Bandirippuwa Research Station to Library – On January 01
7. Mr. W.A.H.Upali, Field Officer from Genetics Resource Center Maduruoya to Walpita Research Station – On January 25
8. Mr. D.M.I.S.K.Dewameththa, Asst. Superintendent from Genetics Resource Center Rathmalagara to Genetics Resource Center Maduruoya – On January 23

9. Mr. A.P.C. Pradeep, Supervisor from Genetics Resource Center Pallama to Genetics Resource Center Ambakelle – On February 06
10. Mr. T.M. Rodrigo, Lab & Field Attendant from Genetics Resource Center Pallama to Genetics Resource Center Ambakelle – On March 15
11. Mr. I.M.S.K. Idirisinghe, Research Officer from Technology Transfer Division to Agricultural Economics Division – On June 01
12. Mr. S.D.J.N. Subasinghe, Senior Technical Officer from Agronomy Division to Agricultural Economics Division – On June 01
13. Mrs E. Pathiraja, Research Officer from Soils & Plant Nutrition Division to Agricultural Economics Division – On June 01
14. Mr. Rohitha Abeysekara, Asst. Research Officer from Agronomy Division to Agriculture Economic Division – On June 01
15. Mr. M.A.S. Fernando, Supervisor from Poththukulama Research Center to Genetics Resource Center Ambakelle – On August 15
16. Mr. A.P.C. Pradeep, Supervisor from Genetics Resource Center Ambakelle to Poththukulama Research Center – On October 02

8. LOCAL TRAININGS (More than 5 days)

1. Mr. L R M C Liyanage/Assistant Research Officer followed a certificate Course on Geographical Information Systems at the Geo- informatics society , from 24 April – 28 April
2. Mr. R Sarathchandra/Senior Book Keeper followed a course on Oracle Database Administration & Application Development at Sri Lanka Institute of Development Administration From 18 June (5 months, Every Saturdays)
3. Mr. W M U Ratnayake/Estates Superintendent followed a Advanced Diploma in Computer course at Sri Tec Computer College, Pallama, 3 months, from 15 July (03 months, 3.00 p.m.to 5.00 p.m.)
4. Mr. D P Panditharatne/Senior Technical Officer and Mr. L R M C Liyanage/Assistnat Research Officer, followed a training of trainers on recent advances in Micro-Irrigation at University of Peradeniya from 30 October to 10 November
5. Mr. Mr. M G M K Meegahakumbura/Research Officer, Mr. B A S Manjula/Assistant Research Officer and Mr. A A Fernando/Technical Assistant followed a Training course on Radiation Safety in using Radioisotopes for Research & Industrial Applications at Atomic Energy Authority from 11 – 15 December
6. Miss. H D Mangalika/Administrative Officer followed a Diploma course on Human Resource Management at National Institute of Business Management one year from 25 November (Every Saturdays).

9. OVERSEAS VISITS

1. Dr. D.B.T.Wijeratne/Chairman, Coconut Research Board attended the Overseas Market Development Programme in Osaka, Japan from 29 April to 08 May.
2. Dr. I.R.Wickramananda/Senior Research Officer participated in the Exchange of Scientists programme of IPM project between Sri Lanka & India in India from 25 to 31 May.
3. Mr. K.F.G.Perera/Senior Technical Officer participated in the Exchange of Scientists programme of IPM project between Sri Lanka & India in India from 25 to 31 May.
4. Mr. R.P.B.H.S.Senaratne/Research Officer participated at the Annual project evaluation meeting on "Overcoming poverty in Coconut growing communities, Coconut Genetic Resources for sustainable livelihood" in Bogor, Indonesia from 12 to 21 June.
5. Mrs. P.I.P.Perera/Research Officer participate to present a paper for the 11th International Association for Plant Tissue Culture & Biotechnology Congress in Beijing, China from 12 to 19 August.
6. Dr. T.S.G. Peiris/Head, Biometry Division participated at the 3rd International Conference on Climate Impacts Assessment to present paper entitled "Assessment of climate change impact & vulnerability of Coconut sector in Sri Lanka in Cairns, Australia from 22 to 28 July.
7. Dr(Mrs) W.N.I.S.C.Fernando/Senior Research Officer participated at the 11th International Association for Plant Tissue Culture & Biotechnology Congress in Beijing, China from 13 to 18 August.
8. Mrs. N.S.Aratchige/Research Officer participated at the International Congress of Acarology and to defend the thesis at the University of Amsterdam in Amsterdam, The Netherlands from 18 August to 13 September.
9. Dr(Mrs) L.C.P.Fernando/Head, Crop Protection Division participated to present an invited paper and attend the 12th International Congress of Acarology in Amsterdam, The Netherlands from 19 to 28 August.
10. Mr. R.P.B.H.S.Senaratne/Research Officer participated at the 7th International workshop on "Biological Control & Management of *Chromoleana Adorata* and *Micania Micrantha*" at National Pingtung University of Science & Technology, Taiwan from 12 to 15 September.
11. Dr. A.A.F.L.K.Perera/Head, Genetics & Plant Breeding Division participated a workshop on "Population structure phenotypic information & association studies in long generation crops in Spain from 14 to 21 October.

10. OVERSEAS TRAININGS

Mrs. D.C.L.Hapuarachchi/Senior Technical Officer participated for short-term training on Mycoacaricide production (Insect pathology techniques) at the CABI Bioscience, United Kingdom from 18 May to 03 June.

11. NO-PAY LEAVE

Mr. M.R.D.Perera/Technical Assistant had permission to follow a Ph.D. programme in University of Glamorgan, UK on no-pay leave from 01 September 2006 to 31 August 2009.

12. TRANSPORT UNIT

Administration of the staff of the unit including drivers and maintenance of the following fleet of vehicles were done by the Transport Unit during the year 2006.

Buses	-	03
Lorries	-	02
Vans	-	08
Cars	-	01
Cabs	-	13
Jeeps	-	05
Motor bicycles	-	61
Three Wheelers	-	<u>02</u>
		95
		==

13. DEBTORS DUE TO VIOLATORS OF BONDS

Name	Bond Value
1. Dr. K.B.Dasanayaka	Rs. 2,039,715.00
2. Mr. H.P.S.Jayasundara	Rs. 2,078,905.33
3. Mrs. M.G.F.S.Jayasundara	Rs. 3,345,424.66
4. Mr. R.A.J.R.Perera	Rs. 1,068,165.00
5. Mr. M.A.Thilakasiri	Rs. 927,906.52
6. Mrs. P.G.P.Hewawitharanage	Rs. 2,993,945.18
7. Dr. (Mrs) C.K.Banadaranayake	Rs. 3,371,612.63
8. Mr. N.A.K. De Silva	Rs. 3,204,297.60

14. FINANCE UNIT

Total budgetary allocation for this year is 155.7 million and out of which 130.7 million under recurrent and 25 million under capital expenditure. Therefore the government grant was 137 million.

Preparing Institutional Budget cash flow and the final accounts are main functions of the Unit in addition to preparing monthly salaries and making routine payments.

15. ENGINEERING UNIT

Engineering Unit carried out maintenance work of buildings, electricity, vehicles, and machineries and attended to the following construction and rehabilitation works during the year 2006.

- Construction Boundary wall and Gate for Middeniya Research Station.
- Supply & installation Drip Irrigation system for Isolated Seed Garden.
- Construction Office & Training Centre at Middeniya Research Station
- Extra repair works of the Guest House.
- Construction of a Pump house.
- Rehabilitation of existing roads.
- Rehabilitation of Insectary building at Bandirippuwa Research Station
- Renovation of CPRD office at Head office.
- Construction of Agriculture Economics Division.
- Renovation of staff quarters BE/III/34 at Bandirippuwa Research Centre
- Renovation of staff quarters BE/GR/III/23 at Bandirippuwa Research Centre
- Renovation of staff quarters BE/GR/I/16 at Bandirippuwa Research Centre
- Renovation of staff quarters BE/GR/I/22 at Bandirippuwa Research Centre

**STAFF PUBLICATIONS/COMMUNICATION
AT SCIENTIFIC MEETINGS**

Bandrarnayake, C K (2006). "An effective population size for reliable map resolution of coconut" (*Cocos nucifera* L.)". *CORD* 22(2): 33-40.

Bandaranayake, C K and Perera, L (2006). "Hybrid coconut CRIC 65: Recent findings". *Coconut Technology Update*, CRI 2: 2-5.

Ekanayake, G K, Bandaranayake, C K, Dassanayake, P N and Everard, J M D T (2006). "Morphological Diversity of new coconut phenotypes identified from Unawatuna and neighbouring villages in the Southern Province". *Proceedings of the 62nd Annual Session, Sri Lanka Association for the Advancement of Science*, p.44.

Fernando, S C, Weerakoon, K, Gunathilake, T and Ambagala, I (2006). Micropropagation of coconut through plumule culture. Poster presented at 11th International Association for Plant Tissue Culture and Biotechnology, Biotechnology and Sustainable Agriculture 2006 and Beyond, August 13-18, Beijing, China.

Gunathilake, H A J, Joseph, P G and Peiris, T S G (2006). Sustainable biomass production in Sri Lanka and possibilities for agro-forestry intervention.

Kularatne, J D J S, Peiris, T S G and Samita, S (2006). Feasibility of single palm plot in coconut experimentation. *Journal of Tropical Agricultural Research*, 18, 306-314.

Kumarasinghe, W M, Perera, S A C N and Gunasekara, T M C P (2006). "Evaluation of morphological differences and yielding ability of nut colour based phenotypes of Sri Lanka tall coconut". *Proceedings of the 6th Agricultural Research Symposium, Faculty of Agriculture and Plantation Management. University of Wayamba*. Pp. 307-310.

Lakmini, W G D, Nainanayake, N P A D and de Costa, W A J M (2006). Biochemical changes of four different coconut (*Cocos nucifera* L.) forms under moisture stress conditions. *The Journal of Agricultural Sciences* 2: 1-7.

Lakmini, W G D, Nainanayake, N P A D and de Costa, W A J M (2006). Screening of coconut (*Cocos nucifera* L.) for drought tolerance. 11th International Forestry and Environment Symposium, December 22nd – 23rd. 24p.

Lakmini, W G D, Nainanayake, N P A D and de Costa, W A J M (2006). Physiological responses of four coconut (*Cocos nucifera* L.) genotypes under water stress. *Proceedings of the International Symposium, Sabaragamuwa University of Sri Lanka*. 4-8 July, 2006. (Proceedings in press).

Lakmini, W G D, Nainanayake, N P A D and de Costa, W A J M (2006). Genotype environment interaction as a tool for screening drought tolerant coconut (*Cocos nucifera* L.) genotypes. 62nd Annual Scientific Session of Sri Lanka Association for the Advancement of Science (SLASS). December 10th – 15th. 20-21.

Madurapperuma, W S (2006). Heat ratio method to determine the sap flow in palms. Proceedings of the 62nd Annual Scientific Session of Sri Lanka Association for the Advancement of Science (SLASS). December 10th – 15th. 19.

Malauire, B, Bandupriya, H D D, Fernando, S C and Verdiil, J L (2006). Optimisation du procede de cryoconservation de la plumule de cocotier. Les Actes du BRG, 6: 449-468.

Marrikkar, J M N Jayasundara, J M M A, Fernando, W S R and Peiris, T S G (2006). Fortification of coconut oil with sesame oil through micro expeller extraction process. CORD 22 (2), 15-21.

Meegahakumbura, M G M K (2006). "Exotic germplasm: Key for the future of coconut breeding in Sri Lanka". Coconut Technology Update, CRI, 2:7.

Peiris, T S G, Appuhamy, P A H N, Nainanayake, N P A D, Bandaranayake, C K and Fernando M T N (2006). Coconut research development and dissemination of technologies – growers' perception. Diagnostic survey report. Coconut Research Institute, Lunuwila, 61150, Sri Lanka.

Peiris, T S G Hansen, J W and Zubair, Lareef (2006). Use of seasonal climate information to predict coconut production in Sri Lanka for publication in Int.J of Climatology.

Peiris, T S G, Appuhamy, P A H N, Nainanayake, N P A D, Bandaranayake, C K and Fernando, M T N (2006). Coconut research development and dissemination of technologies – grower's perception. 102pp.

Perera, L (2006). Coconut germplasm conservation and research with molecular markers at the Coconut Research Institute of Sri Lanka". Proceedings of the symposium on Molecular markers for allele mining". M S Suwaminathan Research Foundation, Chennai, India, 22-26 August 2005. p 43.

Perera, L, Bandaranayake, C K and Perera, S A C N (2006). "Molecular markers in coconut breeding: Current status and future possibilities". Proceedings of the symposium on "Application of Biotechnology in Agriculture". Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo. Pp. 14-19.

Perera, P I P, Hoher, V, Weerakoon, L K, Verdiil, J L and Yakandawala, D M D (2006). Recent advances in anther culture of coconut (*Cocos nucifera* L). In: Abstracts of 11th International Association for Plant Tissue Culture and Biotechnology;

Biotechnology and Sustainable Agriculture 2006 and Beyond, August 13-18, Beijing, China.

Perera, P I P, Hocher, V, Verdiil, J L, Yakandawala, D M D and Weerakoon, L K (2006). Anther Ovary and ovule culture of coconut. Poster presented at 10th Annual Ceremony of PGIS.

Perera, S A C N and Ekanayake, G K (2006). "Conservation of coconut biodiversity in Sri Lanka". Coconut Technology Update, CRI, 1: 1-2.

Perera, S A C N (2006). "Validation of DArT technology for coconut by developing a medium resolution coconut tree array". Final technical report submitted to Generation Challenge Program of the IPGRI.

Perera, S A C N, Wilkes, T M and Kearsley, M J (2006). "More precise QTL mapping using STAIRS. Tropical Agricultural Research 18: 227-236.

Ranasinghe, C S, Fernando, W M U and Bandaranayake, C K (2006). "Enhancing the income and employment opportunities in the coconut sector through conservation and sustainable use of special coconut ecotypes". Coconut Genetic Resources, IPGRI. Edited by Pons Batugal, V Ramanatha Rao and Jeffrey Oliver. Pp. 586-589.

Ranasinghe, C S, Peiris, T S G, Jayawardene, J K J P, Perera, L, Fernando, M T N and Wickramananda, I R (2006). Coconut palm decline disorders – a survey on incidence and probable causes, Coconut Research Institute, Lunuwila, Sri Lanka.

Ranasinghe, C S, Peiris, T S G, Jayawardene, J, Perera, L, Fernando, M T N and Wickramananda, I R (2006). Coconut palm decline: An assessment of the prevalence and probable causes. CRI survey report. 35 pp.

Sabelis, M W, Takabayashi, J, Janseen, A, Van Wijk, M Sznajder, B, Aratchige, N S, Lesna, I, Belluire, B, Kant, M and Schuurink, R C (2006). Chemically mediated, indirect effects on arthropod communities. In: Ohgushi, T, Craig, T P and Price, P W (eds.) Indirect Interaction on Webs: Nontrophic through induced plant traits.

Waidyaratne, K P, Peiris, T S G and Samita, S (2006). Shift in onset of first inter monsoon rain in coconut growing areas in Sri Lanka Journal of Tropical Agricultural Research, 18 1-13.

Wijsekara, H T R (2006). Taxonomic studies on the genus *Colletotrichum* and its molecular characterization. Ph D thesis submitted to Postgraduate School of Indian Agricultural Research Institute, IARI, New Delhi, India.

Wijesekara, H T R and Agarwal, D K (2006). Studies on five species of the genus *Colletotrichum*. *Indian Phytopathology*. 59: 203-209.

Wijesekara, H T R, Aggarwal, R and Agarwal D K (2006). Morphological and molecular characterization of five *Colletotrichum* species from India. *Indian Phytopathology*. : 448-453.

Training and Extension Activities

Research and technical staff participated as resource personnel in many training programmes for Agriculture teachers and students, Agriculture extension officers and Coconut Development Officers.

Ms S R M Ranaweera of Wayamba University of Sri Lanka carried out a six-month industrial training as a partial fulfillment of B Sc (Agric) degree from Dec 2005 to June 2006 under the supervision of Dr C S Ranasinghe.

Ms W G D Lakmini of University of Ruhuna completed her M Phil project on 'Physiological and biochemical changes of different coconut genotypes under moisture stress' from January to July under the supervision of Dr N P A D Nainanayake.

Ms K K S R Dayaratne, of University of Peradeniya completed her B Sc final year research project on 'Evaluation of physiological and biochemical changes of two coconut genotypes grown under different moisture regimes' from May to October, 2006 under the supervision of Ms W S Madurapperuma.

Messers Y D Jayawardane and S Weerakoon of NAITA, Veyangoda completed a 4-month training course from May to August 2006 under the supervision of Ms W S Madurapperuma.

Messers H M A B Herath, B H N A P Buwanekabahu, D M S L Ratnayake of NAITA, Veyangoda completed a 3-month training course from August to October 2006 under the supervision of Ms W S Madurapperuma.

Dr. L Perera, Dr. (Mrs.) C K Bandaranayake, Dr. (Miss) S A C N Perera and Mr. R Jayathilake conducted four, two days-workshops on 2-3 February 2006, 2-3 March 2006, 6-7 April 2006 and 4-5 May 2006 for CCB officers on "Coconut seed production and nursery management"

Dr. (Miss) S A C N Perera delivered a lecture on "Coconut Breeding" at the training programme organized by CCB for training newly recruited nursery officers, 18 September 2006.

Mr. R Jayathilake delivered a lecture on "Coconut seedling production and seedling certification service" at the training programme organized by CCB for training newly recruited nursery officers, 18 September 2006.

The division staff involved in organizing and conducting the first programme of the One day training programme series of year 2006 of the CRI on "Replanting of coconut" at the Isolated Seed garden, Ambakelle, 26 May 2006

The division staff participated in three Crop Clinic programmes conducted at MOSG, PRS and RE

Dr. L. perera participated in two research extension dialogues held at Kaluthara and Polonnaruwa.

Dr. (Miss.) S A C N Perera participated in the research extension dialogue held at Madamulana, 10 March 2006.

The division staff delivered lectures for many groups of students, farmers, and growers who visited CRI and Isolated Seed Garden.

A substantial number of school children, students of technical colleges, undergraduates and graduates visited the division, molecular biology laboratory and the Isolated Seed Garden at Ambakelle.

Dr. N.A. Tennakoon participated as a resource person in 2 programmes on Usage of Eppawela Rock Phosphate for coconut held in Chilaw and Matale organized by Phosphate Lanka (Pvt) Ltd, Colombo.

Dr. N.A. Tennakoon participated as a resource person in training programme conducted by Coconut Development Training Centre and NIPM.

Dr. N.A. Tennakoon participated as a resource person in 3 of one day training programme on Fertilizer for coconut, Irrigation for coconut and Rehabilitation of coconut lands conducted by Coconut Research Institute.

Dr (Mrs) W.C. Fernando, Miss. M.K. Fathima Nadheesha and Mrs. H.M.I.K. Herath participated as resource persons in one day training programme on fertilizer for coconut conducted by Coconut Research Institute.

Academic and professional Activities

Dr. (Miss) S A C N Perera served as a judge for the Biotechnology session 6th Agricultural Research Symposium of the Faculty of Agriculture and Plantation Management, Wayamba University, Makandura, 21 November 2006

Miss. H. D. M. A. C. Dissanayaka served as the chairperson for the Plantation Management session of the 6th Agricultural Research Symposium of the Faculty of Agriculture and Plantation Management, Wayamba University, Makandura, 21 November 2006

Dr. L Perera served as a judge for the Genetics and Biological Conservation session of the 17th Annual Congress of Postgraduate Institute of Agriculture, PGRC, Peradeniya, from 27 to 28 November 2006.

Dr. L Perera served as a referee of research papers (biotechnology) to Tea Science Journal of the Tea Research Institute, Sri Lanka, Journal of the National Science Foundation of Sri Lanka.

Dr. L Perera served as a referee of research papers (biotechnology) to Acta Botanica Croatica (International Journal of the University of the Zagreb, Croatia)

Dr. L Perera served as a referee of research papers (Germplasm conservation) to the Plant Genetic Resources Newsletter, IPGRI

Dr. L Perera and Dr. (Mrs.) C K Bandaranayake served as referees for research papers submitted to PGIA Annual Congress (2006) and SLASS (2006).

Dr. (Mrs.) C K Bandaranayake served as a referee for science journal of the National Science Foundation of Sri Lanka.

Dr. (Mrs.) C K Bandaranayake and Dr (Miss) S A C N Perera served as referees for science journal of the Sabaragamuwa University of Sri Lanka.

Dr. (Miss) S A C N Perera supervised the final year research project of Mr. W.M.Kumarasinghe of the Faculty of Agriculture and Plantation Management of the University of Wayamba on "Evaluation of morphological differences and yielding ability of nut colour based phenotypes of Sri Lanka tall coconuts".

Dr. (Mrs.) C K Bandaranayake served as the external supervisor to Mr. G K Ekanayake, M.Phi student of the University of Sri Jayawardanapura, Colombo.

Dr (Mrs) W.C. Fernando supervised the B.Sc final year research project of Miss. Ranga Gunasiri of University of Kelaniya. The title of the project was 'Changes in the community structure of fungi and bacteria in coconut cultivating soils treated with different types of fertilizer'.

Dr (Mrs) W.C. Fernando supervised the B.Sc final year research project of Miss. Gaya Karunasinghe of Kelaniya University. The title of the project was 'Estimation of arbuscular mycorrhiza in coconut treated with different types of fertilizer'.

Dr (Mrs) W.C. Fernando supervised partly the B.Sc final year research project of Mr. D.J. Kumara of Ruhuna University with the study of Arbuscular mycorrhizal fungal status in organically managed coconut at Ratmalagara Estate.

Dr. N.A. Tennakoon and Mrs. H.M.I. K. Herath supervised B.Sc (Agric) final year research project of Mr. A.P.A. Samyakumara in University of Ruhuna. The title of the project was "Characterization of nutrient status analysis of different soil series in coconut growing soils".

Meetings, workshops and seminar participation

Dr. L Perera participated in the workshop on "Capacity building needs to ensure benefits from providing access to genetic resources" HARTI, Colombo from 5-6 January 2006.

Dr. L Perera participated in the second FAO training workshop on "Establishment of a national information sharing mechanism on the implementation of the global plan of action (GPA) for the conservation and sustainable utilization of plant genetic resources for food and agriculture" Hotel Tree of Life, Kandy, from 28 to 29 April 2006.

Mr. M G M K Meegahakumbura participated in the third FAO training workshop on "Establishment of a national information sharing mechanism on the implementation of the global plan of action (GPA) for the conservation and sustainable utilization of plant genetic resources for food and agriculture" Hotel Tree of Life, Kandy, from 17 to 18 July 2006.

Dr. (Miss) S A C N Perera participated as a resource person and delivered a lecture on "Genome mapping and applications" at the workshop on "Application of modern biotechnology in plant genetic Resources Analysis & Plant Breeding" organized by CARP, from 19 to 20 November 2006

Dr. L Perera participated as a resource person and delivered a lecture on "Using molecular markers in breeding coconut in Sri Lanka" at the short course on "Using molecular markers for improving the efficiency of plant breeding in Sri Lanka" Organized by Council for Agricultural Research (CARP), Michigan State University, USA and Coconut Research Institute, Lunuwila, CARP Auditorium, Colombo from 6 to 8 December 2006.

Dr. (Miss) S A C N Perera participated as a resource person and delivered a lecture on "Fine mapping and marker assisted breeding" at the short course on "Using molecular markers for improving the efficiency of plant breeding in Sri Lanka" Organized by Council for Agricultural Research (CARP), Michigan State University, USA and Coconut Research Institute, Lunuwila, CARP Auditorium, Colombo from 6 to 8 December 2006.

Dr. L Perera participated in the final workshop on "Establishment of a national information sharing mechanism on the implementation of the global plan of action (GPA) for the conservation and sustainable utilization of plant genetic resources for food and agriculture" Hotel the Village, Polonnaruwa, from 8 to 9 September 2006.

**REPORT OF THE ACCOUNT UNIT
FINANCIAL PERFORMANCE REPORT
Accountant - R M U Chandranath, BSc Mgt., FCBA**

The Coconut Research Institute's receive its maintenance funds from the Treasury and other incomes generated from four Genetic Resource Centres, five Research Centres, CESS grant , Divisional income through services and, Donor Funded Projects Grants etc.. Table 1 shows the funds received from the treasury, income generated through self-financing units, CESS grants and donor funded projects grant for the last four years.

Due to financial limitations, allocation and utilization of available resources were made more effectively and efficiently to achieve organizational objectives. Planning and organizing the institute so as to maintain the financial strength and stability, investment plan was established to generate additional funds and to monitor the institute's resources.

Table 1: Grants from Treasury, income from self-finance units, CESS and donor projects

Sources	Rs. Million			
	2003	2004	2005	2006
Treasury Grant – Recurrent	52.77	60.27	77.00	99.80
Treasury Grant – Capital	27.50	22.26	24.60	12.40
Income Self-finance Units	46.98	55.00	58.62	68.77
CRI Own Income	5.75	4.98	5.76	6.57
CESS Grant	12.50	20.67	57.48	55.00
Donor Funded Projects	7.72	8.45	7.29	8.18
Total	153.22	171.63	230.75	250.72

As shown in Table 1, the recurrent grant has increased by 8.7% in the year 2006 compared to year 2005. The income generated by self-financing unit operations for the year increased by 17% to reach Rs, 68.77 Mn..

Table 2: Financial progress of recurrent and capital expenditure

Description	Rs. Million		(Decrease) % Increase
	2005	2006	
Personnel Emoluments	78.05	96.36	24%
Travelling Expenses	1.38	1.63	18%
Supplies and Requisites	9.39	10.48	12%
Maintenance Expenses	12.68	16.76	32%
Contractual Expenses	4.07	5.40	33%
Other Recurrent Expenses	5.47	2.82	(48%)
Total Recurrent Expenses	111.04	133.45	20%
Total Capital Expenses	21.61	09.79	

The staff position of the CRI was 789 employees during the year 2006. Out of them 328 were permanent employees and 461 were daily paid workers in research substations and

genetic resources centres. As indicated in Table 2, 72% of the total recurrent expenditure was on personnel emoluments and the next highest expenditure was on maintenance such as buildings, vehicles, electricity, infrastructure development etc. Fuel and lubricant were included under supply expenditure and telephone, Internet, insurance, security charges, legal fees etc. included under contractual services.

Table 3 : Financial Progress of Self-financing Units

Seed Gardens/ Research Centers	Year 2006		Surplus/ (Deficit)
	Income Rs. Million	Expenditure Rs. Million	
Ambekela Genetic Resources Center	18.12	13.57	4.5
Pallama Genetic Resources Center	6.33	6.11	0.2
Makandura Genetic Resources Center	8.52	4.00	4.5
Maduruoya Genetic Resources Center	5.73	4.32	1.4
Bandirippwa Research Staton	9.41	9.30	0.1
Rathmalagara Research Center	8.23	8.33	-0.1
Walpita Research Center	2.91	2.07	0.8
Pottukulama Research Center	8.64	6.71	1.9
Dunkannawa Research Center	0.88	1.72	-0.8
Estates Management Division		0.22	
Total	68.77	56.35	12.42

Pallama Genetic Resource Canter and Dunkannawa Research Canter had been vested recently and therefore these two estates are in an improvement stage.

**COCONUT RESEARCH INSTITUTE
GENETIC RESOURCE CENTRES & RESEARCH SUBSTATIONS**

ITEM	BANDIRIPPA RESEARCH STATION	LATHMALAGAR RESEARCH CENTRE	GENETICS RESOURCES AMBAKELLE	OTTTHUKULAM RESEARCH CENTRE	WALPITA RESEARCH CENTRE	GENETICS RESOURCES MAKANDURA	GENETICS RESOURCES MADURUOYA	GENETICS RESOURCES PALLAMA	DUNKANNAWA RESEARCH CENTRE	ESTATE MANAGEMENT DIVISION	TOTAL 2006	CUMULATIVE 2005
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
GENERAL CHARGES	3,155,028.63	3,074,902.48	4,132,537.80	2,381,390.70	624,813.06	1,294,399.17	1,569,327.34	2,536,870.08	401,332.68	120,275.17	19,290,877.11	16,223,751.40
SUPERINTENDENT & STAFF	2,933,770.11	2,871,532.47	3,606,401.88	1,895,971.53	662,160.62	1,284,605.52	722,459.33	2,194,370.45	550,653.57	106,056.89	16,827,982.37	17,275,481.37
UPKEEP	1,079,909.04	1,004,629.16	2,228,573.34	519,383.36	466,722.83	282,854.03	1,113,001.68	326,160.96	656,650.34		7,677,884.74	6,971,246.52
CULTIVATION	991,151.37	646,589.41	2,152,550.59	1,011,133.59	144,375.44	543,057.88	602,299.17	556,926.80	75,160.28		6,723,244.53	5,810,735.01
HARVESTING	651,418.66	484,885.49	1,024,642.56	579,537.49	149,872.77	284,250.56	308,149.25	417,471.39	26,927.32		3,927,155.49	2,907,263.65
TOTAL COST OF PRODUCT.	8,811,277.81	8,082,539.01	13,144,706.17	6,387,416.67	2,047,944.72	3,689,167.16	4,315,236.77	6,031,799.68	1,710,724.19	226,332.06	54,447,144.24	49,188,477.95
CURING INTO COPRA/DISPOSE	171,135.11	67,553.69	116,413.35	177,564.23	22,332.12	81,307.65	9,054.72	73,987.00	5,786.96		725,134.83	420,584.04
ANIMAL HUSBANDRY	318,305.80	175,120.41	312,301.03	149,511.37	2,675.00	148,782.17		2,500.00			1,109,195.78	938,004.19
TOTAL EXPENDITURE	9,300,718.72	8,325,213.11	13,573,420.55	6,714,492.27	2,072,951.84	3,919,256.98	4,324,291.49	6,108,286.68	1,716,511.15	226,332.06	56,281,474.85	50,547,066.18
SALES OF COPRA	528,755.80	170,552.10	50,443.35	157,306.00	8,701.00	127,482.00	25,928.00	175,743.60	204.00		1,245,115.85	1,438,996.26
SALES OF COCONUT	5,540,559.75	5,397,125.98	16,938,745.46	8,806,120.28	1,429,560.68	5,669,535.71	4,546,088.42	5,682,059.59	160,273.48		54,170,069.35	43,341,749.78
SALES OF SEEDLING	104,370.00	488,160.00	465,896.66		123,300.00	54,075.00	519,567.90		650,935.00		2,406,304.56	2,349,615.00
SALES OF SUNDRIES	1,028,512.90	433,158.61	205,299.83	140,689.80	1,122,130.53	128,328.30	15,587.30	372,394.88	8,265.00		3,454,367.15	3,758,990.24
SALE OF ANIMALS PRODUCE & ANIMAL	735,381.76	290,392.09	377,359.50	670,693.46	79,068.00	639,433.00	10,478.52		15,245.47		2,818,051.80	1,003,981.55
	7,937,580.21	6,779,388.78	18,037,744.80	9,774,809.54	2,762,760.21	6,618,854.01	5,117,650.14	6,230,198.07	834,922.95		64,093,908.71	51,893,332.83
STOCK VARIANCES	1,474,251.90	1,451,156.50	81,219.72	-1,131,172.64	145,823.60	1,897,153.00	609,691.00	95,783.05	47,764.00		4,671,670.13	6,723,856.82
ADJUSTED INCOME	9,411,832.11	8,230,545.28	18,118,964.52	8,643,636.90	2,908,583.81	8,516,007.01	5,727,341.14	6,325,981.12	882,686.95		68,765,578.84	58,617,189.65
SURPLUS/(DEFICIT)	111,113.39	-94,667.83	4,545,543.97	1,929,144.63	835,631.97	4,596,750.03	1,403,049.65	217,694.44	-833,824.20	226,332.06	12,484,103.99	8,070,123.47
LESS - AMORTIZATION & DEPRICIATION	312,915.20	408,221.10	849,046.85	371,531.00	76,008.50	199,611.95	423,838.77	248,478.26	125,688.37		3,015,340.00	2,934,342.91
NET SURPLUS/(DEFICIT)	-201,801.81	-502,888.93	3,696,497.12	1,557,613.63	759,623.47	4,397,138.08	979,210.88	-30,783.82	-959,512.57	226,332.06	9,468,763.99	5,135,780.56
TRANSFER TO HEAD OFFICE CHARGES											4,000,000.00	4,000,000.00
											5,468,763.99	1,135,780.56