COCONUT RESEARCH BOARD

COCONUT RESEARCH INSTITUTE OF SRI LANKA

REPORT FOR 2008

COCONUT RESEARCH INSTITUTE - REPORT FOR 2008

COCONUT RESEARCH BOARD

REPORT OF THE COCONUT RESEARCH INSTITUTE FOR 2008

Editor
C.Jayasekara, PhD (Qld)

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The member of the Board as at 31st December 2008

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*** Mr W J L S Wijeweera resigned with effect from 25th July**

*** Dr M H J P Fernando resigned in August.**

COMMITTEES OF THE COCONUT RESEARCH BOARD

As at 31st December 2008

The Research Committee

Name

Dr. U. Pethiyagoda
Dr. D.T. Wettasinghe
Mr. Densil Aponso
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Dr. Sunil Jayasekera
Mr. Parakrama Jayathilaka
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Dr. R.R.A. Wijekoon
Mr. Gamini Samarasinghe
Mr. Nimal Mithraratne

The Audit & Management Committee

Name

Mrs J M S D Rathnayake, Chairperson
Mr W J L W Wijeweera, Member
Dr J D H Wijewardena, Member
Dr (Mrs) C Jayasekara, Director/CRI
Mr E P Gunapala, DD(A&F)/CRI
Mr J Sunil Shantha, Superintendent of Audit

Estate Committee

Mr.J M D T Everard	Chairman
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Dr. N A Tennakoon	Member
Mr. P A H Nimal	Member
Dr. C S Ranasinghe	Member
Dr. S H S Senarathne	Member
Mr. A N T D Kumara	Member
Mr. K. Meegahakumbura	Member

CONTENTS

COCONUT RESEARCH INSTITUTE OF SRI LANKA

THE STAFF
(As at 31st December 2008)

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

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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), Ph.D.(Peradeniya)

Agronomist

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

Assistant Research Officer

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

Senior Technical Officers

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M J I Costa
R Marasinghe, B.Sc.(Agric),
M.Sc(Animal Production System)
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Senior Lab/Field Assistants

E M Gunaratne Banda
W S M A Fernando
H B Perera
K D D Appuhamy
R A Swarnathilake

Lab/Field Assistant

W R O Fernando

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Agronomist

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

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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 Prematthilake, B.Sc.(Agric)
R I B C T Herath, B.Sc.(Agric), M.Sc.
M N Nadeeranga, B.Sc.(Agric)
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A A Fernando

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Soils & Plant Nutrition Division

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

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M.Phil(Peradeniya, M I Biol, Ph.D

Soil Scientists

Mrs. H M I K Herath, B.Sc.(Agric),
M.Sc.(Soil Management)
Miss M K F Nadheesha, B.Sc.(Chemistry),
M.Sc.(Food Technology)

Assistant Research Officer

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

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E M A Thilakaratne Banda
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Mrs. H L A Padmini, Dip. (Agric)
M R D Perera, B.Sc.(Sci) ***

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W Gunasena
F H A J R Silva

Lab/Field Assistant

K J S Perera

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Senior Entomologist

Mrs. N S Aratchige, B.Sc.(Agric), Ph.D. (Amsterdam)

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

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W K M K Herath

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

Botanist

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

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E S Shantha

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

Principal Plant Physiologist

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Senior Plant Physiologist

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

Plant Physiologists

B H C Mendis, B.Sc.(Botany)

Senior Technical Officers

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R D N Premasiri

L R S Silva

Senior Lab/Field Assistant

A Jayathilake

Coconut Processing Research Division

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

Senior Food Technologist

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M.Sc.(India)

Food Technologist

Miss J M M A Jayasundara, M.Sc.
(Analytical Chemistry) (Peradeniya)

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

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Senior Extension Officers

A M A P G Gunawardena, B.Sc.(Agric)
M.Sc. (Agric. Extension)

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M.Sc.(Peradeniya)**

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M.Sc.(Peradeniya)
J K J P Jayawardena, B.Sc.(Agric),
A R U Ratnesekara, B.Sc.(Agric),
E M T Bandaranayake, B.Sc.(Agric),
M.Sc.(Peradeniya)

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W G L Rodrigo

Senior Clerk/Typist

R A L C Fernando

Senior Lab/Field Assistant

H P Ashoka Kumara

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Assistant Librarian

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

Senior Clerk/Typist

Mrs. S N Gunathilaka

Administration

Deputy Director (Administration & Finance)

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

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Miss. H D Mangalika, B.A., LLB

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Mrs. P C A Fernando
A S Nanayakkara

Supplies Officer

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

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Mrs. S Z Suhair

Senior Stenographer (English)

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Mrs. H M W S Athauda
Mrs. H M A Herath

Senior Clerk/Typist

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Mrs. W S R Fernando
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Mrs. M G Karunawathi
M A D M F Appuhamy

Clerk/Typist

J K C W N Perera

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Internal Auditor

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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

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Accountant

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

Senior Book Keepers

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

Senior Shroff

M C H N Fernando

Senior Store Keeper

M B U Wijetunga

Senior Audit Clerk

M R U Attanayake

Senior Accounts Clerks

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

Accounts Clerks

Mrs. W A N K Wijesinghe

Senior Clerk/Typist

Mrs. A A N P Kanthi

Engineering Unit

Resident Engineer

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

Works Superintendent

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

Senior Foreman (Mechanical)

R Vithanage

Senior Draughtperson

Mrs. R M S Ratnayake

Senior Clerk/Typist

K T G N W Perera

Clerk/Typist

M Somasiri

Senior Mortor Mechanic

R M S G Rantnayake

Senior Mason

W M Dhanapala

Senior Carpenter

A A K Amarasinghe

Linesman

S R P Jayamanna

Estates Management Division

Acting Manager (Estates)

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

Senior Clerk/Typist

W P R R Fernando
W A L R Fernando

Bandirippuwa Main Research Centre

Superintendent

I A N Hemasiri

Senior Supervisor

A G B G Silva
A A Sirinimal

Supervisor

W M N G Wijayatunga

Ratmalagara Research Centre

Superintendent

G B A Wijesekara

Assistant Superintendent

H B S Herath

Clerk/Typist

D M Jayawardene

Senior Supervisor

T M Keerthiratne

Ambakelle Genetics Resources Centre

Superintendent

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

Assistant Superintendent

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

Supervisor

M A S Fernando

Senior Supervisor

M P W Fernando

Senior Clerk/Typist

J A R Reginold

Maduruoya Genetics Resource Centre

Assistant Superintendent

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

Field Officer

G P N Chandrasiri

Middeniya Research Centre

Assistant Superintendent

K Liyanarachchi, B.Sc.(Agric)

Supervisor

W M D R Wijesianghe

Dunkannawa Research Centre

Officer-in-Charge

N Gamage

Walpita Research Centre

Officer-in-Charge

W A H Upali

Poththukulama Research Centre

Officer-in-Charge

D L J Neththasinghe

Supervisor

M G D D Placidus

Makandura Genetic Resource Centre

Officer-in-Charge

W A H Upali

Supervisor

A P C Pradeep

Pallama Genetic Resource Centre

Superintendent

W M U Ratnayake, Dip in Plantation Management

Assistant Superintendent

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

Senior Supervisor

W W A P R Fernando

Clerk/Typist

H M Podiratne

Lab & Field Assistant

H A P B Fernando

** Study Leave
*** No pay 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 11 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 2008 are given below:

Name	Record of attendance
Dr D B T Wijeratne, Chairman	12/12
Dr M H J P Fernando, Member	05/12*
Mr N Mithraratne, Member	05/12
Mr J V R Dias, Member	08/12
Dr J D H Wijewardana, Member	09/12
Mr W J L S Wijayaweera, Member	03/12 *
Mrs J M S D Rathnayake, Member & Treasury Representative	05/12
Mr D J U Purasinghe, Member	05/12
Mr P G Dassanayake, Member	09/12
Dr H A J Gunathilaka, Member	10/12
Dr (Mrs) C Jayasekara, Director, CRI/Member	12/12

* Mr W J L S Wijeweera resigned with effect from 25th July
* Dr M H J P Fernando resigned in August.

The Research Committee

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

Name	Record of attendance
Dr. U. Pethiyagoda	2/6
Dr. D.T. Wettasinghe	-
Mr. Densil Aponso	5/6
Vidya Jyothi Dr. Ray Wijewardana	3/6
Dr. Sunil Jayasekera	4/6
Mr. Parakrama Jayathilaka	5/6
Prof. M.de. S. Liyanage	1/6
Dr. J.D.H. Wijewardena	-
Prof. Sumith Jayasekera	2/6
Chairman/CRB	5/6
Director/CRI	6/6
Deputy Director (Research)	6/6
Dr. Sriyani E. Peiris	1/1
Prof. Tilak Attanayaka	1/1
Dr. Shantha Ramanayaka	1/1
Dr. K.K.S. Fernando	1/1
Prof. Jayanthi Edirisinghe	1/1

Prof. Rohan Rajapakse	-
Dr. Chandra Jayasinghe	1/1
Dr. Manel Dassanayake	1/1
Dr. S.S.P. Kuruppuarachchi	2/2
Prof. R.B. Mapa	1/1
Dr. Lalani Samarappuli	1/1
Prof. S.S.E. Ranawana	-
Prof. R.O. Tatil	-
Dr. Lakshman Rodrigo	1/1
Prof. J.M. De. Costa	1/1
Dr. Janaki Goonerathne	1/1
Prof. U. Samarajeewa	1/1
Prof. G. Fonseka	-
Dr. K.H. Sarananda	1/1
Ms. S.A. Samadara Dissanayaka	1/1
Mr. Ananda Hettiarachchi	-
Mr. Krishan Karunasena	-
Mr. Indrajith Piyasena	-
Dr. J.M.U.K. Jayasinghe	1/1
Dr. W.A.S.P. Wanigasundara	1/1
Dr. R.R.A. Wijekoon	-
Mr. Gamini Samarasinghe	-
Mr. Nimal Mithraratne	-

The Audit & Management Committee

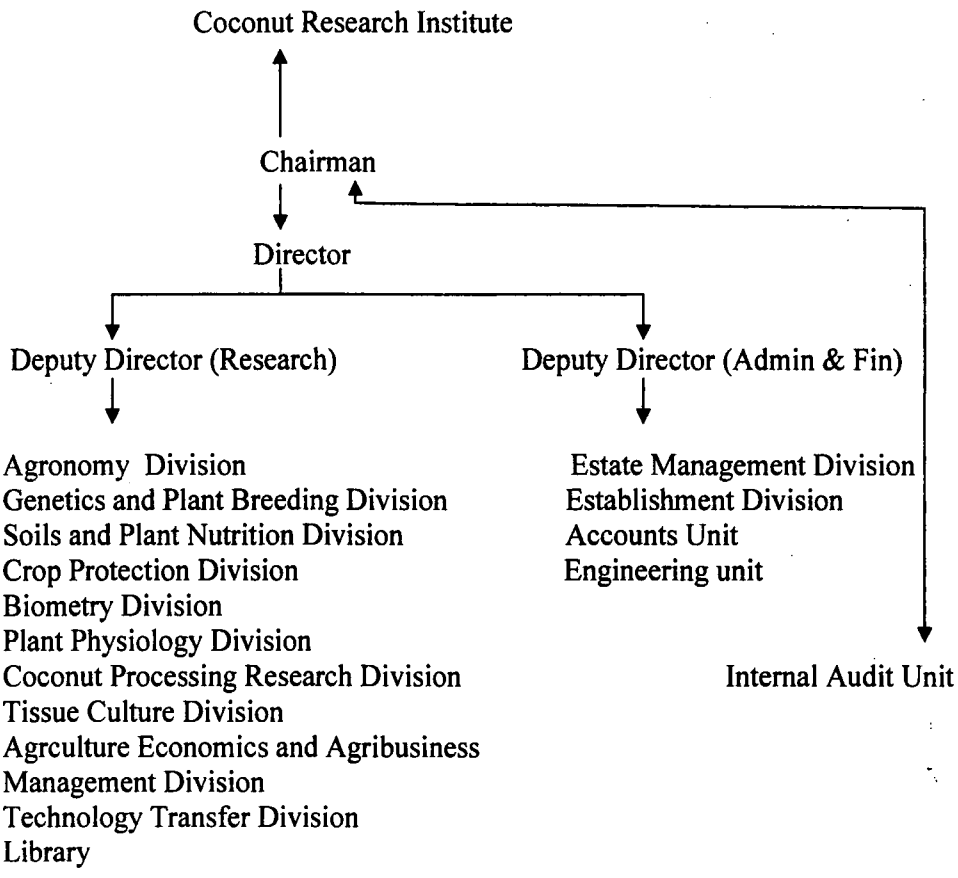
The members of the Committee and their attendance are given below:

Name	Record of attendance
Mrs J M S D Rathnayake, Chairperson	04/04
Mr W J L W Wijeweera, Member	02/04
Dr J D H Wijewardena, Member	04/04
Dr (Mrs) C Jayasekara, Director/CRI	04/04
Mr E P Gunapala, DD(A&F)/CRI	04/04
Mr J Sunil Shantha, Superintendent of Audit	04/04

Management

The Director who is responsible for the implementation of all policies and programs laid down by the Board and 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.

REPORT OF THE DIRECTOR

C. Jayasekara, PhD

Summary

Coconut industry suffered a severe set back in 2008 despite the high farm gate prices recorded during the first three quarters of the year. The coconut prices dropped by almost a 100-fold in the fourth quarter of the year due to crashing of fossil fuel prices. The acute global recession also attributed for the sudden drop in coconut prices. Due to high demand for bio-diesel in developed countries in the preceding year the palm oil prices have increased by almost 100% in 2007. This resulted the highest ever prices for coconut in first three quarters of 2008. Consequently the average farm gate price of coconuts increased to as high as Rs 23.00 per nut with retail price of fresh coconuts recording Rs 27.30. With the fall in fossil fuel prices, the recession and the reduction of tariff from 28% to 5% for import of edible oils the prices of fresh coconuts and coconut products fell sharply to almost the cost of production. Due to government's intervention by bringing tariff back to 28%, the prices of coconut and its products reached a satisfactory level towards the end of the year.

CRI predicted coconut yield for 2008 as 2,776 million nuts. The nut production, calculated on collecting pick wise data of representative samples from different regions estimated the actual total production as 2,871 million nuts which differed by only 3.3% from the predicted yield. Most of the coconut growing areas experienced a high and a well distributed rainfall during the year, 2008. This even distribution of rainfall is likely to contribute to an increased nut production in 2009.

The performances of research, technical as well as supporting staff of research and services divisions were very satisfactory during the year. The dedication and commitment of the staff to achieve the set targets of the institute despite one third of the staff positions being vacant is noteworthy. The vacancies created due to retirements at the age of sixty and resignation of some staff. At certain instances duties of some vacant positions had to be covered by trainees and contract staff of specific projects. CRI worked jointly with TRI, RRI and SRI to prepare a common scheme of recruitment and promotions for all the four institutions. This scheme is now in near completion. Among other notable activities of the year, CRI took the lead role in organizing the Second Plantation Crop Symposium which provided a forum for scientists of Coconut, Tea, Rubber, and Sugar Cane Research Institutes to present research findings to respective stake holders. CRI has also provided its fullest support to organize the 45th annual ministerial meeting of the Asia Pacific Coconut Community, which took place in December, 2008 at the Galle Face Hotel, Colombo.

Most serious challenge faced by the CRI during the year was to develop a management strategy for Weligama Coconut Leaf Wilt Disease (WCLWD), which emerged in alarming proportions in the Southern part of Sri Lanka in 2007. The institute has given highest priority for managing WCLWD with the initiation of a multidisciplinary research programme aiming at developing an accurate diagnostic procedure for early detection of the disease, assessing the extent and depth of the disease, carrying out pathological and entomological investigations, estimating crop damage, identifying correlations between palm health, soil status and palm management on disease vulnerability and recommending alternative farming packages for farmers of severely affected areas. Further a joint operation was commenced with the assistance of Coconut Cultivation Board and the Department of Agriculture to prevent the spread of the disease to other coconut growing areas in the country by

demarcating a 3-km wide 240-km long disease free zone around the affected area and declaring the disease prevalent area as a quarantine zone.

Despite the priority given for WCLWD research program other research activities, especially the long term research activities of the institute too were implemented successfully during the year. Amongst these, developing new promising cultivars, popularizing the use of locally available nutrient resources and organic farming, effective harvesting of water and irrigation in coconut lands, weed control studies, plant physiological studies of diverse nature, climatic studies, testing high valued intercrops, developing animal husbandry models for coconut lands, developing coconut and gliricidia integrated bioenergy production, managing major and minor pests and diseases of coconut, developing new products and processors, carrying out socio economic analyses and technology transfer programs were noteworthy activities attended uninterruptedly during the year.

Multidisciplinary research approach introduced a few years ago has accounted for a significant progress in overall research output of the institute. Soil fertility, irrigation, and WCLWD research activities mostly benefited by interdivisional collaboration.

New findings of these studies have been translated into simple technology packages for the growers to reap the desired benefits. It is noteworthy that these research achievements were well recognized by the growers as well the scientific community of the country. The institute was brought to pride in 2008 by a CRI scientist winning the gold medal for the best research paper of papers from all plantation research institutes (CRI, TRI, RRI and SRI) at the 2nd Symposium on Plantation Crop Research held from 16-17, October, 2008 in at BMICH, Colombo.

Allocation of Funds

Coconut Research Institute receives funding from three sources, consolidated fund, donor assisted funds and a part of income from estates of CRI and from services provided to the sector.

The total Allocation from the treasury for the year 2008 was Rs 314.908 million of which shares of Capital and Recurrent Funds were Rs 136.667 million and Rs 178.241 million respectively. This is respectively 13% and 10% more than capital and recurrent funds received compared to the previous year. From the capital allocation Rs 14 million was reallocated to provide funds for the WCLWD management and research programme due to its urgency and national importance. However, total receivables from the treasury as the Capital funds for 2008 were only Rs 58 million out of the allocated Rs 136.667 million. Committed liabilities for import orders of chemicals, glassware, equipment, building constructions, and other services were nearly Rs 30 million. As funds were not made available from the 2008 for these expenditure this amount has to be brought forward to the 2009 capital budget. Meager disbursement of capital funds from the treasury was the main reason for this situation. Nevertheless, institute addressed the challenges it faced successfully giving high priority for the most important issues of the industry by sacrificing reconstruction and maintenance activities without becoming a burden to the government.

Achievements and Highlights:

1. Research:

1.1 Crop Improvement

Planting of four multi-locational trials and two observational trials with exotic crosses developed by crossing local cultivars with imported pollen of four exotic varieties from Ivory Coast was one of the highlights of the CRI coconut breeding programme. A new crossing programme to produce San Ramon x Dwarf Brown and Tall x Dwarf Brown was also commenced during the year to plant them in the farmer's fields as adaptive trials to complement the research fields planted with reciprocal crosses of these hybrids in multi locations. Other main research activities of the division such as evaluation of cultivars, evaluation of progenies, evaluation of crosses with exotic varieties, evaluation of dwarf crosses and expansion of existing gene banks continued successfully. Main molecular biology activities of the institute were the genotyping of new coconut varieties and DNA based diagnosis of Weligama Coconut Leaf Wilt Disease (WCLWD).

Tissue Culture research programme placed much emphasis on culture of unfertilized ovaries which were shown to be the most promising explants for clonal propagation of coconut. However, tissue culture response of explants was observed to be highly genotypic dependent. Therefore, attempts were made to identify most responsive genotypes. Promising results were obtained from plumule culture, when plumules were obtained from several tissue cultured plants of a single clone. Over 250 plantlets were regenerated from the calli derived from these plumules. Out of 347 Dikiri embryos cultured during the year, 165 *in-vitro* raised plants were produced. Sixty plants of this were established at the Middeniya Research Center. A greater success was achieved with coconut anther culture, which was aimed at developing dihaploid coconuts to enhance cost and time constrained conventional coconut breeding efforts.

To complete planting of the Pallama Seed Garden (PSG), 2034 seedlings were field established. Self pollination of San Ramon at Pottukulama Research Station (PRS) and PSG was continued for the production of planting material for further expansion of PSG. The production of CRISL 98 and Kapruwana seed nuts by hand pollination at ISG and PSG for commercial issues of seedlings was continued.

1.2 Crop Production

Agronomy research programme of the institute addresses research problems for developing or improving technologies for increasing coconut production and productivity and enhancing the profitability of coconut lands through better agronomic practices. In this regard more attention was given for studies on moisture conservation, bio-energy production in coconut lands, organic farming with intercropping and animal husbandry, cultivation, management and utilization of nitrogen fixing trees.

Planting density studies of gliricidia with coconut revealed that there is good potential for planting wood for foliage biomass four years after planting. The highest wood and foliage biomass was obtained in plots with three and two rows of gliricidia, while the lowest yield recorded in plots with a single row of gliricidia. However, plots with higher plant densities had a low wood and foliage biomass per tree.

In addition to traditional crops as intercrops with coconut, a new intercropping experiment was initiated to popularize cut foliage in mature coconut plantations for increasing farmer's income. Three foliage varieties namely Cane palm, Queen palm, and Cordiline species were used for this study. Cordiline reached to the harvesting stage in five months and showed highest leaf formation.

Under the bio-energy development project, a model was established with six buffalos, 1 ha of gliricidia + coconut with natural pastures and supply of paddy straw from outside. Animal dung was used to generate bio-gas for cooking and to generate electricity for the housing unit. Excess buffalo dung and sludge from the bio-gas plants were used to fertilize coconut. This model unit consisting one hectare of coconut + gliricidia + natural pasture + paddy straw from outside with six buffaloes was able to produce green energy equivalent to 5,700 units of electricity (kWh) or 8550 liters of diesel, in addition to farm income derived from coconut, buffalo milk and other benefits of buffalo farming. The total return from this model unit was Rs 1,379,520 per year.

Organic coconut farming is gaining popularity among coconut growers. To popularize organic coconut production and processing, 29 coconut-based organic farming models were established in the coconut triangle. These farms are being supervised and monitored with necessary guidance and inputs such as livestock, gliricidia sticks, and other intercrops. In order to enhance profitability and fertility of small holder coconut lands an animal breeding project was initiated in 1999 with the financial assistance of coconut Cess Fund. A project is underway to develop low cost leaf meal for animals to overcome the scarcity of feeds during the dry season.

A long term experiment conducted with different sources of phosphates revealed that Eppawela Rock Phosphate could be used as a source of P especially in wet and intermediate zones. This study further assessed the accumulation of Cd in soil, leaf, kernel and nut water after long-term application of phosphate (17years). Triple super phosphate, imported rock phosphate, and Eppawela rock phosphate were the three sources of phosphates used. None of them have exceeded the contaminated level (soil, 0.5mg/kg, plant material, 0.2mg/kg). Nevertheless there is a tendency in accumulation of Cd in the kernel of IRP treated coconut palms than ERP treated palms.

Multi-locational experiment conducted with fertilizer doses higher than recommended revealed a significant yield increase with higher doses of fertilizer. This study further revealed that recommended dosages of fertilizer as the adult palm mixture is not sufficient to achieve high yields of coconut. With the escalation of prices of inorganic fertilizer it is not practical to advise growers to add more inorganic fertilizers. Therefore, as an alternative, coconut growers are encouraged to apply organic fertilizer together. with minimum supplementary levels of inorganic fertilizers. Further, application of organic and green manure and inorganic fertilizer as separate treatments revealed that a 27 % increase in nut yield could be gained by poultry manure application. Other organic sources namely cattle manure, goat manure, and gliricidia as a green manure gave 25%, 30%, and 9% yield increases respectively over the control.

The forecasted Annual National Coconut Production for 2008 was 2776 million nuts. The estimated production value up to October 2008 was3.7% more than the predicted value for the same period. The highest per palm yield recorded was from Monaragala followed by

Ampara CCB regions up to October 2008. Based on survey data the per capita consumption of oil and fresh nuts were 7.3 bottles and 101 nuts for 2007. According to the survey carried out on percentage nut losses due to mite infestation were 17.6 and 10.2 respectively in 2006 and 2007. This clearly shows a decreasing trend in nut losses due to mite infestation.

1.3 Crop Protection

The new disease outbreak, "Weligama Coconut Leaf Wilt Disease" (WCLWD) was the main focus of the scientists working on pests and diseases. By the end of the year the disease was also reported from the Hambantota district in addition to Matara and Galle Districts. Strategies were formulated to prevent the spread and improve the status of diseased palms. These include issuing a gazette notification prohibiting transport of live palms and their parts out of the affected areas, demarcation of a boundary around the diseased area to maintain a disease- free area, commencement of a survey to assess the extent of the diseased area and the disease intensity. An extensive multi-disciplinary research programme was commenced and a laboratory was established at Weligama to facilitate research activities.

Previous year CRI was able to identify causative agent of this disease as a Phytoplasma. An ELISA method was developed to detect phytoplasma in diseased palm tissues. A preliminary experiment revealed that tender inflorescence stalk is the most suitable tissue for staining by the Diene's stain for the detection of phytoplasma. An index considering the characteristics; flaccidity (F), yellowing(Y), and marginal necrosis (N) was developed to identify the severity stages of WCLWD affected palms and apparently healthy palms for field experiments. Spaying of spore suspensions of antagonist fungi *Aspergillus niger* and *Trichoderma viridae* to the bud region of the leaf rot affected palms did not show any improvement. Nevertheless, suppression of yellowing symptom of WCLWD affected palms was observed when 5g/ml of oxy-tetracycline plant formula was trunk injected.

The current recommendation of treating red weevil infested palms with monocrotophos was revised and new increased dosages were recommended.

The research on coconut mite was continued with studies on population dynamics of the pest and its natural enemies and developing management strategies using biological and chemical methods. Technology was developed to release predator mite *Neoseiulus bakari* to the field. The percentage of nuts and nuts that are sold at half price were lowest in the plots where 5000 predators/palm were released at 2 monthly intervals. In a separate study it was found that the release of predatory mites to a quarter of an acre at the rate of 5000 mites per palm at bi-monthly intervals reduces the percentage of nuts that are sold at half price at the harvest. Mass scale releases of predatory mites in the Maduruoya Seed garden resulted in higher predatory mite populations in released blocks compared to unreleased blocks. The survey carried out on percentage nut losses due to mite infestation in selected coconut mite infested regions at bi-monthly intervals for 2006 and 2007 revealed that percentage nut losses were 17.6 and 10.2 respectively. This clearly indicates that there is a decreasing trend in nut losses due to mite infestation.

The pilot study conducted to confirm effectiveness of spraying the fungus, *Hirsutella thompsonii* at 3-monthly intervals to manage coconut mite did not show improvement in damage levels of treated palms. Therefore this study was discontinued.

A study conducted at the laboratory level revealed that the Sri Lankan isolate and the Philippine isolate of the entomopathogenic fungus *Metarhizium anisopliae* perform equally well with respect to growth and spore production at different temperatures and virulence to black beetle larvae. A study was commenced to determine the effect of releasing *Oryctes* virus infected beetles in reducing black beetle damage. Another study was commenced to determine effect of pheromone-baited traps on the control of black beetle population. A total of 2,700 wild beetles were caught within a six month period.

The multidisciplinary research programme on coconut palm decline syndrome was continued at Makandura Research Station. A new experiment was commenced to estimate the impact of Weligama Coconut Leaf Wilt Disease on morphological, physiological, and yield aspects of affected palms. Disease severity index was developed employing a scoring system on three major morphological symptoms viz. flaccidity, yellowing, and marginal necrosis. Samples from leaf mid rib and flower stalks were sent to a USA laboratory for nano imaging to identify the presence of any sub-cellular pathogens associated with the disease.

1.4 Coconut Processing:

Coconut processing research programme of the institute continued with more emphasis on quality and process improvement of traditional coconut products and development of new kernel based products. In addition to food products much emphasis was placed on development of value added products from byproducts mainly coir based products.

The cured copra packed in gunny bags or poly urethane bags cannot keep longer because of the short shelf life. Therefore, a study was initiated to improve keeping quality of copra by introducing a suitable packaging system. It became evident from this study that when copra is stored under different packing systems the poor packaging reduces keeping quality of copra. Packaging of copra in nylon LDPE under vacuum packing and metalized polyethylene improved shelf-life and quality of copra (moisture content <0.5%, oil content >64%, free fatty acid level,0.6%).

A study was conducted to develop a pasteurized coconut milk pouch for house hold consumption. Coconut milk diluted to 20% fat with water used for this study. The study revealed that pasteurization of coconut milk at 72^0C for 30 minutes and packaging in nylon polyethylene and aluminium laminated polythene pouches were equally effective in maintaining shelf-life of coconut milk up to 4 weeks.

During the process of burning coconut shells to produce charcoal lot of heat is wasted and the smoke generated causing environment pollution. To utilize this waste heat and to address the issue of environmental pollution a gasifier, flue gas burner, heat exchanger and a hot air dryer was designed and fabricated in collaboration with the private sector. A thermal rating gasifier with 16-20 kg /hr crushed coconut shell feeding capacity and up to 60 Kw gasifier was fabricated. To separate various particles coming with the flue gas from the burner a cyclone separator was also developed. The flue gas pumped towards gas burner gave a blue

colour flame, temperature went up to 850 ^{0}C and the exhaust gas was colour less as well as odour less. The heat generated inside the gas burner transferred to a dehydration chamber through a heat exchanger. Within the drying chamber pulverized coconut kernel dried at a temperature of 70^{0}C reduced moisture level up to 2-3% within four hours. This heat recovery unit could be used to cut down energy cost for coconut kernel drying but capital investment for the locally fabricated heat recovery unit is approximately Rs 2 million.

Conventional retting of coir needs more than six months. In order to develop appropriate technology to reduce retting period and to improve productivity of coir industry a consortium of micro-organism was isolated from several sites. Several retting trials were conducted at the laboratory level to isolate highly effective micro-organisms in the medium.

1.5 Socio-economics

Six major socio- economic studies were conducted during this year by the Agriculture Economics and Agribusiness Management Division. They were a) Economic implications of indiscriminate fragmentation of coconut lands, b) Effect of land size on productivity of coconut cultivation, c) Technology demand in brown coir fiber sector, d) An ex-post evaluation of technology in virgin coconut oil industry, e) Cost of production of coconuts and F) Developing a framework for estimation of coconut land extent in Sri Lanka.

The study carried out using the applications received by the Coconut Cultivation Board for land fragmentation revealed that some land owners take hidden action by neglecting fertilizer application and other management practices purposively to reduce coconut yield or they do not expose exact productivity figures to the Fragmentation Control Board to achieve their hidden objective of getting approval for fragmentation. The study conducted to determine the effect of land size on productivity revealed that a significant negative relationship exists between land size and productivity of coconut lands in Sri Lanka for home gardens and smallholders, where as the productivity of estates increases as the land size increases from 21 acres onwards up to 40 acres.

The study on technology demand for brown fiber sector revealed that the superior quality of bristle fiber obtained from Sri Lankan drum pair cannot match with any other fiber extraction machines available. Therefore, it is very important to introduce improved new technology to over-come shortage of skilled labour and to increase productivity of traditional drum pair system. Other studies are progressing satisfactorily.

1.6 Services offered to the Industry by the Research Divisions

Genetics and Plant Breeding Division has produced 11,665 and 3832 CRISL 98 and DGSR (Kapruwana) seeds respectively by hand pollination for raising seedlings for adaptive trials in farmer's fields. Tissue culture division sold 140 embryo cultured dikiri plants among growers.

Agronomy Division maintains a herd of goats at Pottukulama research station. From this herd fifty male and female goats were sold to coconut growers to establish goat farming units. Similarly buffaloes and cows also distributed to farmers at one third of the live weight value of animals to popularize livestock farming in coconut lands.

Soils and Plant Nutrition Division provided Differential Fertilizer Recommendation (DFR) for 91 growers covering an extent of 2,215 ha during the year. Further, the division involved in quality testing of 290 fertilizer samples, 213 organic manure samples and 565 coir pith samples were analyzed and certificates were issued for export purposes.

Crop Protection Division continued to serve the coconut growers by advising on management of pests and diseases whenever their assistance requested, while field inspections were made in instances where specialized advice was required. Infestations of coconut caterpillar were successfully managed by releasing nearly 404,400 laboratory bred parasitoids. A total of 3210 pheromone vials were sold for the control of red weevil.

Baculo virus and green muscardine fungus made available to the growers for the control of black beetle.

2. Technology Transfer Activities

Technology transfer activities of the institute focused more towards to give wide publicity and raise awareness among the growers and general public about the Weligama Coconut Leaf Wilt and Leaf Rot Diseases prevalent in the Southern part of Sri Lanka. Several awareness programmes were conducted in Matara, Galle, and Hambantota Districts for Coconut Development Officers, Village Agriculture Research and Development Assistants, Samurdhi Officers, Gram Niladharis, School Children and Police Officers. A special booklet giving symptoms of the diseases and management strategies was published in Sinhalese and English. Posters, hand-outs and photographs were also distributed among officers and growers in the area. A special video documentary was produced to be used in educational programmes. An extensive media coverage was given through print and electronic media.

Ten educational programmes were conducted for groups of Coconut Growers, Estate Management Staff of Plantation Companies and the members of the Coconut Growers Association. Seven one day educational programmes were conducted for Coconut Growers and Estate Staff in the Head Office and Substations. Nearly 250 participants attended the programme this year. Four training the trainer programmes were conducted for Agrarian Research and Development Assistants in Hambantota District.

As a tool for promoting technologies among small holders twelve farmer Field School (FFS) programmes were conducted in Kuliyapitiya, Ratgama, and Middeniya areas. Educational and familiarization programmes were conducted for students and teachers of ten schools and six higher educational institutions. Over 15 training programmes were conducted in various parts of the island to promote new coconut based products among small and medium scale entrepreneurs in collaboration with the officers in VIDATHA Centers or AGA Divisions.

In order to promote the application of organic manure for coconut plantations, a farmer participatory field demonstration was implemented in collaboration with the Coconut Growers Association.

A new series of Advisory Bulletins in the subject areas of Fertilizer application for coconut, Land suitability for coconut cultivation, Pests and diseases of coconut, and Coconut based products in an attractive colour format. Two issues of Technology Updates and Cocos vol.18 were also published. Second interactive CD on coconut based products was prepared in collaboration with Coconut Processing Research Division and the Audio visual center of the Dept of Agriculture at Gannoruwa.

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 Estate Management Division. Part of the profits (Rs 11 Million) generated by the Division contributed to the Institute.

During the year a total of 4,995,087 nuts were produced by the total palm population comprising 75,417 fully bearing palms and 3,400 partially bearing palms. The yield included 1,366,455 seed nuts from Genetic Resources Centers The overall cost of production (COP) for all estates averaged as Rs 12.66 with a net sales average of Rs 21.27. The gross income from all the estates was Rs. 113.49 million and total expenditure was Rs. 75.09 million giving the net profit of Rs. 38.397 million.

4. Maintenance of Institute properties and new constructions:

Engineering Division attended to urgent building, vehicle, roads, water, and electrical repair and maintenance activities. Major building renovations were not undertaken due to scarcity of funds .

4.1. New Constructions:

The construction of the new Soils and Plant Nutrition Laboratory was completed and the building was handed over to the institute in August.

5. New Initiatives:

5.1 Water Supply Scheme

To overcome the shortage of water at Bandirippuwa Estate a water supply scheme from the Ma-Oya water scheme was proposed. It was postponed to next year due to scarcity of funds.

6. Human Resource Development:

6.1 Postgraduate training:

Miss J M M A Jayasundara, Research Officer undertook to follow a postgraduate degree in Food Technology at the University of Queensland, Australia from 01 January 2008.

6.2 Overseas training

1) Mrs. P I P Perera, Research Officer participated at the Training and Research Workshop on Coconut Embryo Culture organized by the Coconut Genetic Resource Network held in the Philippine from 09 to 12 December 2008.

2) Mr. M G M K Meegahakumbura, Research Officer participated at the Training and Research Workshop on Coconut Embryo Culture organized by the Coconut Genetic Resource Network held in the Philippine from 09 to 12 December 2008.

3) Dr L Perera participated in a workshop on "Population structure, phenotypic information and association studies in long-generation crops in Zaragoza, Spain" from 16 to 20 October.

6.3 Local Training

1) Mrs. K P S Jayathilaka, Senior Clerk/Typist followed a Diploma in Human Resource Management at National Institute of Business Management from 26 November 2008 (one year) – Amount Rs. 65,000.00.

2) Mrs. W S R Fernando, Senior Clerk/Typist followed a Diploma in Business Management at National Institute of Business Management from 26 November 2008 (one year) – Amount Rs. 65,000.00.

7. Outputs of the Institute:

7.1 Awards:

1. Dr. P I P Perera, Senior Research Officer, Tissue Culture division was the recipient of three national awards during the year.

   I. Third World Academy of Science / National Science Foundation (TWAS / NSF) Young Scientist Award for the scientific excellence in the field of Biology (2008).

   II. Gold Medal for the best paper presentation of the 2nd Symposium on Plantation Crop Research (2008).

III. Postgraduate Research Merit Award 2008 at sixty fourth annual sessions of Sri Lanka Association for the Advancement of Science.

2. Dr. N.S. Aratchige, Senior Research Officer, Crop protection division was the recipient of " Hiran Thillekerathne Research Fund award" for the most outstanding postgraduate research in agriculture" presented by the CARP.

3. Miss. H D M A C Dissanayaka, Research Officer, Genetics and Plant Breeding Division was the recipient of silver medal for the best paper presentation in the Coconut Sector at the 2ndSymposium on Plantation Crop Research.

4. Dr. L. Perera was the recipient of international grant valued US $ 30,000.00 from the IPGRI for characterization of indigenous germplasm.

5. Dr. H.A.J. Gunathilaka awarded, National Science and Technology Awards, 2008 of National Science foundation. The theme was "Giricidia as a fuel crop com and Substitute for Fodder and Fertilizer", under category of development of eco- materials / eco– friendly processes for industry. The others were Vidya Jothi Dr. Ray Wijewardana, P.G. Joseph and Parakrame Jayasingha.

6. Wijesekara, H T R, Perera L, Wickramananda, I R, Hearth, I, Meegahakumbura M K, Fernando, W B S and de Silva P H P R received the best Poster award in the coconut sector at the second Plantation Crop Research Symposium, BMICH, Colombo (2008) for the poster titled "Weligama Coconut Leaf Wilt Disease: A new disease in Southern Sri Lanka".

7.2 Innovation of new machinery;

Coconut Processing Research Division in collaboration with the private sector designed and fabricated a burner for coconut shells, gasifier and a waste heat recovery unit at a cost of Rs 1,500,000.00 to produce charcoal and to dry pulverized coconut kernel.

7.3 Technologies provided to the industry:

CRI has given the technology for virgin coconut oil production to 4 entrepreneurs at a nominal cost of Rs.50,000.00 per project file. The technology for coconut paste was given to 5 entrepreneurs.

Acknowledgements

The co-operation extended by the Deputy Director (Research), Deputy Director (Adm. & Fin.), Heads of Divisions and staff of the Research and Service Divisions for successful implementation of the annual action plan of the institute is gratefully acknowledged.

Valuable contributions made by the Chairman and Members of the Coconut Research Board and those who served in various committees are also acknowledged with deep appreciation.

Continued support given by the following organizations is also acknowledged:

- Ministry of Plantation Industries
- General Treasury
- Coconut Cultivation Board
- Coconut Development Authority
- Tea Research Institute
- Rubber Research Institute
- Department of Agriculture
- Sri Lanka Council for Agricultural Research Policy
- National Science Foundation
- Department of Botany, University of Peradeniya
- Faculty of Agriculture, University of Peradeniya
- Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo
- Wayamba University
- Industrial Technology Institute
- National Science & Technology Commission (NASTEC)
- Kurunegala Plantations Ltd.
- International Mycological Institute, UK
- Food & Agricultural Organization (FAO)
- Common Fund for Commodities
- Direct Fund for International Development (DFID)
- Generation Challenge Programme
- Coconut Genetic Resources Network (COGENT)
- Asian Pacific Coconut Community (APCC)

REPORT OF THE AGRONOMY DIVISION
Acting Head - S.H.S.Senarathne, PhD

1. SUMMARY

The Agronomy research program was primarily aimed at increasing the coconut production and land productivity through development of innovative agronomic practices. In this contest, priority was given to research on rehabilitation of low yielding coconut plantations, soil moisture conservation, bio energy production, weed management, intercropping, vermicompost production, popularization of coconut based organic farming systems and animal husbandry as well as on utilization and management of nitrogen fixing trees in coconut lands. The total allocation of consolidated fund for the above studies was Rs 5.47 million. In addition two out side funded projects, namely the Bio-energy development in coconut land (Alternate energy project, Ministry of Science and Technology) and preservation of low cost cattle feed project (National Science Foundation, Rs. 2.6 million) were also in operation during the year.

Experiment conducts to determine biomass production revealed that plant density had significant effect on the wood and foliage biomass yield of gliricidia after four years of planting. The highest wood and foliage biomass was recorded in plots with three rows and two rows of gliricidia respectively 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. Although treatments (Gliricidia planting two raw system(1mx1m) and three raw system (1mx1mx1m) had equal plant densities, the wider spacing gave higher wood and foliage biomass yields. However, planting spacing and pruning height had no significant effect on the foliage and wood biomass yield of gliricidia after four years of establishment.

The study on short rotation forestry tree species showed that, three *Acacia* species namely *A. auriculiformis, A. mangium-1* and *A. mangium-2* followed by *Tectonia grandis* had the highest growth rates as measured by stem girth at 30 cm and 130 cm above ground. The growth rate of *Calophyllum eletum* (Domba) remained significantly low as in the previous years.

Application of glyphosate at the rate of 1.44ai kg ha^{-1} and1.08 ai kg ha^{-1} were found to be cost effective in controlling weeds in coconut nurseries, compared with hand weeding due to high labour wages. However, some research information showed that glyphosate blocked the plant physiological enzyme activities and inhibited the plant root development process. Thus, no research had been carried out on glyphosate to understand its activity on root growth performances in coconut seedlings. To understand the effectiveness of glyphosate on root growth, a project was started with the objective of studying the effect of different concentration of glyphosate on root growth of coconut seedlings.

Intercropping cashew with coconut did not adversely affect coconut yield as observed in previous year indicating cashew as a potential intercrop under coconut. Grafted cashew reached early flowering and yielded within two years of planting followed by air-layered cashew plants. At the age of seven, both vegetative propagated cashew produced cashew yield of over 5.0 kg $tree^{-1}year^{-1}$. Cashew propagated by seeds took more than five years to flower, but from the 7^{th} year onwards, produced the highest yield among other types. To increase the productivity of coconut plantations, a new coconut based intercropping system

was initiated to introduce foliage plant species under coconut. The objective of this study was determining a suitable foliage plant species for intercropping with mature coconut in the low country wet zone. Three foliage varieties, Cane palm (*Areca lutescens*), Queen Palm and *Cordiline* were selected to cultivate at the experimental site due to the current demand in the export market. Initial results revealed that *Cordyline* is the early and quick leaf producer and it shows the better performance than *Arica lutesence* and *Livistona spp.*

Under the bio-energy development project, the model developed consists of six buffaloes, out side supply of paddy straw and green pasture from 1.0 ha land of gliricidia + coconut with natural pastures. In this system bio gas generated for house cooking using buffalo dung. Testing was carried out to run an engine using biogas for generate electricity and it can be used to run water pump to irrigate coconut palms. The objectives of this study were to study total energy picture in a coconut land, total economic out put of coconut buffalo + gliricidia + paddy straw feeding system and to use biogas to uplift the estate activities in coconut lands. Initial results revealed that 1.0 ha model of coconut + gliricidia + natural pasture with out side paddy straw is sufficient to feed six buffaloes. Total gross return of the model was Rs. 0.978 million for this year. Of this, value of energy contributed 53% of the total income.

Prolong cultivation of coconut without proper management of the land has lead to degradation of soils in many areas of the country. To rehabilitate the coconut grown soils, a project was started with the objective of developing a suitable method to rehabilitate the coconut cultivated soils. Three different plant species *Gliricidia sepium, Panicum maximum, Thitonia diversifolia and Gliricidia sepium+ Thitonia diversifolia* namely and their combinations were grown in coconut plantations and incorporation of their biomass into the soil with combination of other agronomic practices to improve the soil fertility.

The project on "Improvement of Soil Fertility in Coconut Lands through Vermiculture" showed promising potential for 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 to convert to compost fertilizer within 5 to 6 weeks by the mediation of earth worm species. Application of inorganic fertilizer for seedling and mature palms has been recommended to have proper plant growth. However, the current CRI recommendation is based only on macronutrients. There has been some evidence of deficiency in micronutrients after 5-10 years of growth. Therefore application of vermicompost can be useful as it provides both macro and micro nutriments. However, organic farming is a new trend in present agriculture. Organic coconut products had a high demand in Europe market at the beginning but now in local market too. Coconut growers could increase their income through this system when compared with inorganic farming system. To popularize this technology, a project was started with the objective of reducing the cost of production in coconut plantations and increases the productivity of coconut estates and to develop organic farming systems in major coconut growing soils.

Twenty model farms were established in the coconut triangle under the Popularization of Organic Coconut Production and Processing Project. These model farms are being supervised and monitored with necessary guidance and inputs such as livestock and other planting material when and where necessary. Under this project two field experiments were established to develop an organic fertilizer based coconut planting system with the objective of evaluating the prospects and constraints of raising coconut seedlings using 100% organic inputs and to study the effect of organic manure application on the yield of coconut.

To develop the animal husbandry sector in coconut plantations, an animal breeding project was started in 1999 to develop a smallholder goat and buffalo farming systems under coconut with the objective of increasing the profitability and fertility in coconut lands. Forty male and female goats were sold to coconut growers to initiate the goat farming units in their estates and six Mura stud buffaloes were sold to buffalo farming units in Pollonnaruwa district to improve the heard quality and production at a concession of price. 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 conducted in Bandirippuwa estate.

2. RESEARCH PROJECTS

PROJECT 1: REHABILITATION OF LOW YIELDING PLANTATIONS

Experiment 1.1: Effect of root pruning and fertilizer application on yield of coconut palms with heavy root mat formation on Coastal Regosols (DL_4/S_5), 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 2008, 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. Harrowing was done within the manure circle as recommended by the Research Committee, 2007.

Treatments: T_1- Control (Removed due to unavoidable circumstances)
T_2-Harrowing + Fertilizer
T_3-Harrowing only
T_4-Fertilizer only

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

Treatments	Nuts palm^{-1}year^{-1}					
	2003	2004	2005	2006	2007	2008
T_2-Harrowing + Fertilizer	56	58	48	53	48	37
T_3-Harrowing only	40	49	29	36	36	36
T_4-Fertilizer only	49	58	44	60	54	36
Significance	n.s.	n.s.	n.s.	*	*	ns
LSD (P=0.05)					16	

The analysis of data in year 2008 did not show any significant difference between treatments (Table 1). This indicates that there are no any significant effects from harrowing in the coconut square. (T_1 was removed due to unavoidable circumstances).

The experiment is in progress.

H A J Gunathilaka and E M G Banda

Experiment 1.2: Rehabilitation of degraded coconut soils through short-term forestry in Andigama Soil Series (shallow phase) at Ratmalagara Estate (IL_1/S_5), 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 sustainable coconut production. The forest tree species used in this experiment have been planted in a Randomized Complete Block Design (RCBD) with three replicates (Table 2).

In year 2008, the three *Acacia* species showed higher growth rates as measured by stem girth at 30 cm and 130 cm above ground (Table 2). *A. auriculiformis* and *A. mangium-2* showed a significantly high stem girth at 30 cm and 130 cm above ground levels when compared with all other species respectively. The growth rate of *Calophyllum eletum* (Domba) remained significantly low as in the previous years.

Table 2: ***Growth of selected forest tree species at Ratmalagara***

Treatments	Stem girth (cm) (at 30 cm above ground)			Stem girth (cm) (at 130 cm above ground)		
	2006	2007	2008	2006	2007	2008
T_1 *A. auriculiformis*	82	78	78.3	66	70	61.6
T_2 *A. mangium-1*	66	70	72.6	62	48	60.6
T_3 *A. mangium-2*	62	58	72.3	58	50	64.6
T_4 *Calophyllum elatum*	22	25	28.6	18	19	25.0
T_5 *Grewia tilifolia*	35	54	58.0	24	44	52.0
T_6 *Macaranga paltata*	58	51	59.0	51	44	50.3
T_7 *Gliricidia sepium*	35	35	48.3	37	31	55.3
T_8 *Tectonia grandis*	54	49	60.6	44	49	50.0
T_9 *Swieteria macrophylla*	36	50	57.6	29	40	46.6
T_{10} *Bridella mooni*	49	42	57.3	41	39	50.0
Significance	n.s.	*	*	n.s.	*	*
LSD (P=0.05)		7.2	9.2		9.45	18.2
CV%		8.3	9.1		12.75	20.6

The experiment is in progress.

H A J Gunathilake, H A Abeysoma and I M Thilakerathne

Experiment 1.3: Use of different plant species to rehabilitate the coconut cultivated soils

Experiment 1.3.1: Rathmalagara Estate (IL_1/S_4) - 2005

Experiment 1.3.2: Ridigama Oya Estate (IL_1/S_4) - 2006

The objective of the experiments was to develop a suitable method to rehabilitate coconut cultivated soils, because prolong cultivation of coconut leads to degradation of soil in many areas of the country. The soil organic matter levels decreased gradually in these lands due to high temperature and some other factors inherent to tropical soils. 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: T_1- Planting *Gliricidia sepium*
T_2- Planting *Gliricidia sepium* + *Tithonia diversifolia*
T_3- Planting *Panicum maximum*
T_4- Planting *Tithonia diversifolia*
T_5- Planting cover crop (*Puereria phasioloides*)
T_6- Control (no plant species)

Table 3: *Biomass production (kg ha^{-1} $year^{-1}$) of different plant species and species* combinations *at Ratmalagara in 2008*

Treatments	Plant density no/ha	Biomass pro_ kg/plant/ time	Lopping interval times/ year	Total biomass production kg/ha/year
T_1- *G. sepium*	2160	6.0 kg	3 times	38,800 kg
T_2- *G. sepium* + *T. diversifolia*	2160+1200	6.0+0.526kg	3 times	40,696 kg
T_3- *P. maximum*	9600	0.273 kg	6 times	15,700 kg
T_4- *T. diversifolia*	2400	0.526kg	3 times	3, 787 kg
T_5- *P. phasioloides*	100% cover	0.563kg/m2	2 times	11,260 kg

Table 4: ***Effect of four different treatments on the yield of coconut (nuts palm^{-1}year^{-1}) at Ratmalagara and Ridigama from 2007to 2008.***

Treatments	Ratmalagara		Ridigama	
	2007	2008	2007	2008
T_1- Planting *Gliricidia sepium*	45	50	45	53
T_2- Planting *G. sepium* + *T. diversifolia*	48	43	52	60
T_3- Planting *Panicum maximum*	46	43	51	50
T_4- Planting *Tithonia diversifolia*	49	46	42	47
T_5- Planting cover crop (*P. phasioloides*)	57	45	52	70
T_6- Control (no plant species)	43	36	45	50
Significance	*	*	ns	*
LSD (P=0.05)	13	12	-	9

The highest biomass production was given by *Gliricidia sepium* (T_1) and *G. sepium* + *T. diversifolia* (T_2) treatments (Table, 3). During the year nut yield of coconut as affected by the application of different soil rehabilitation practices showed significantly different in both experiments (Table, 4). The highest nut yield was recorded in *Gliricidia sepium* planted plots in Ratymalagara experiment and cover crop (*Puereria phasioloides*) planted plots in Ridigama experiment. Soil samples were collected and analyzed to evaluate the biological, physical and chemical properties.

Table 5: ***Effect of different treatments on soil pH, electrical conductivity, soil moisture content and bulk density at Ratmalagara in 2008***

Treatments	pH		Bulk density (g/cm^3)		Soil moisture content		EC µs/cm	
	June	Dec	June	Dec	June	Dec	June	Dec
T_1	5.16	6.46	1.54	1.37	4.03	5.32	13.58	10.25
T_2	5.91	5.12	1.48	1.56	1.32	5.66	12.29	9.30
T_3	5.96	5.92	1.52	1.48	1.07	5.02	14.80	9.20
T_4	6.23	6.16	1.59	1.48	4.41	5.53	14.27	9.91
T_5	6.34	6.42	1.53	1.46	4.58	6.49	14.22	10.49
T_6	5.25	6.10	1.69	1.55	3.82	3.21	13.00	11.06
Significance	*	ns	*	*	ns	*	ns	ns
LSD (P=0.05)	0.84		0.09	0.13		1.21		

Soil bulk density was significantly low in *Gliricidia sepium* planting plots (T_1) and soil moisture content was significantly high in cover cropping with *Puereria phasioloides* (T_5) treatments plots. Electrical conductivity was not different in both sampling times (Table, 5).

The experiments are in progress

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

Experiment 1.4: **Performance of two different varieties of coconut on Andigama Series Lateritic Soils and the effect of irrigation on the growth of deep plant coconut seedlings.**

Experiment 1.4.1: **Bandirippuwa Estate (IL_1/S5) - 2005**

The objective of the experiment was to determine the effect of irrigation on two cultivars of coconut deep planted 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. Husks were buried to conserve soil moisture. Seedling growth was measured and expressed as seedling girth and rate of leaf production.

Treatments: T_1 - With Irrigation + Tall x Tall seedlings
T_2 - With Irrigation + Plus palms seedlings
T_3 - Without Irrigation + Tall x Tall seedlings
T_4 - Without Irrigation + Plus palms seedlings

Table 6: ***Effect of different treatments on the growth of coconut seedlings (expressed as the seedling girth) at Bandirippuwa Estate.***

Treatments	Seedling girth (cm)				
	2006	2007		2008	
	Dec	June	Dec	June	Dec
T_1 - With Irrigation + Tall x Tall seedlings	57	47	53	94	103
T_2 - With Irrigation + Plus palms seedlings	50	47	58	108	119
T_3 - Without Irrigation + Tall x Tall seedlings	49	44	48	82	99
T_4 - Without Irrigation + Plus palms seedlings	52	43	52	95	106
Significance	ns	ns	*	*	*
LSD (P=0.05	-	-	8	14	15

Table 7: ***Effect of different treatments on the growth of coconut seedlings (expressed as the rate of leaf production) at Bandirippuwa Estate.***

Treatments	2007		2008	
	June	Dec	June	Dec
T_1 - With Irrigation + Tall x Tall seedlings	0.44	0.52	0.58	0.70
T_2 - With Irrigation + Plus palms seedlings	0.41	0.59	0.65	0.78
T_3 - Without Irrigation + Tall x Tall seedlings	0.44	0.47	0.48	0.58
T_4 - Without Irrigation + Plus palms seedlings	0.36	0.47	0.54	0.67
Significance	ns	*	*	*
LSD (P=0.05		0.06	0.07	0.05

Growth of coconut seedlings are expressed as seedling girth (cm) and the rate of leaf production (number of leafs per month) (Table, 6 & 7). Both growth parameters were significantly affected by the treatments in December 2008. Coconut seedlings growth in irrigation with Plus palm seedling grown under irrigation (T_2) showed highest seedling girth than the other treatments (Table, 6). Tall x Tall seedling with irrigation treatment (T_1) showed higher growth rate in terms of leaf production rate than the other treatments (Table, 7).

The experiment is in progress.

S H S Senarathne, 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 8. Treatments were arranged in Randomized Complete Block Design with nine effective palms per plot.

Coconut yield data were collected during the year 2008 to capture the pre-treatment variation. There were no significant differences between treatments during the year 2008.

Table 8: ***Effect of husk burial, irrigation and fertilizer application on coconut yield at Ratmalagara Estate***

Treatments	Nut yield (nuts palm^{-1} year^{-1})		
	2006	2007	2008
T_1- Fertilizer only	76	79	71
T_2- Irrigation only	83	85	74
T_3 – Husk pits only	94	87	74
T_4 - Irrigation + husk pits + fertilizer	90	82	76
T_5-Fertilizer + Irrigation into husk pits	86	84	76
Significance	ns	ns	ns
LSD (P=0.05)	-	-	-

The experiment is in progress.

H A J Gunathilake, 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, Iriyagolla (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 Iriyagolla (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 the rate of leaf production.

Treatments: T_1 - Vermi-compost only (100%) + Dolomite

T_2 - Inorganic fertilizer (YPM 100%) + Dolomite

T_3 - Vermi-compost (50%) + Inorganic fertilizer (YPM 50%) + Dolomite

Table 9: ***Effect of different treatments on the growth of coconut seedlings (expressed as the seedling girth, height and leaf production rate at Badalgama in 2008.***

Treatments	Girth (cm)			Height (cm)			Rate of leaf production (number of leaves per month)		
	Jan	June	Dec	Jan	June	Dec	Jan	June	Dec
T_1	27	34	42	206	215	256	0.527	0.467	0.638
T_2	26	31	39	191	193	228	0.516	0.490	0.581
T_3	22	26	34	166	215	234	0.510	0.451	0.621
	ns	*	*	ns	ns	ns	ns	ns	ns
Significance	-	6	7	-	-	-	-	-	-
LSD (P=0.05)									

Table 10: ***Effect of different treatments on the growth of coconut seedlings (expressed as the seedling girth, height and leaf production rate at Iriyagolla in 2008.***

Treatments	Girth (cm)			Height (cm)			Rate of leaf production (number of leaves per month)		
	Jan	June	Dec	Jan	June	Dec	Jan	June	Dec
T_1	28	37	46	239	253	304	0.981	1.17	0.809
T_2	21	34	41	147	230	270	0.975	1.21	0.754
T_3	24	30	37	139	236	273	1.018	1.16	0.786
	*	*	*	*	ns	ns	ns	ns	ns
Significance	3	3	4	38	-	-	-	-	-
LSD (P=0.05)									

During the experimental period, rate of leaf production (number of leaves per month) and seedling height (cm) were not significantly different in both experiments (Table 9 & 10). Seedling girth was significantly high in 100% vermicompost with dolomite applied plots (T_1) in both experiments (Table 9 & 10).

The experiments are in progress.

S H S Senarathne, M.J.I.Costa, K C P Perera and K.D.D.Appuhamy

Experiment 3.2: Use of vermi-compost in coconut based organic farming systems

Experiment 3.1.1: Kebellagara Estate, Dummalasuriya (IL1/S4) - 2008

Low productivity and the higher cost of production of the coconut plantation are the major issues faced by the coconut industry. Higher cost of production of coconut in comparison to the returns has reduced the profitability of coconut plantations dramatically in the recent years. The objectives of this experiment were to reduce the cost of production in coconut plantations and increase the productivity of coconut estates and to develop organic farming

systems in major coconut growing soils. Therefore, one experiment was established at Dummalasuriya (Kebellagara Estate), using following treatments with Randomized Complete Block Design with three replicates. Nut yield and copra content were measured.

Treatments: T_1 - Vermi-compost only (100%) + Dolomite
T_2 - Inorganic fertilizer (APM 100%) + Dolomite
T_3 - Vermi-compost (50%) + Inorganic fertilizer (APM 50%) + Dolomite

Table 11: ***Effect of three different treatments on the yield of coconut (nuts palm^{-1}year^{-1}) at Kebellagara Estate in 2007 and 2008***

Treatments	Nut yield (nuts palm^{-1}year^{-1})	
	2007	2008
T_1 - Vermi-compost only (100%) + Dolomite	35	44
T_2 - Inorganic fertilizer (APM 100%) + Dolomite	32	47
T_3 - Vermi-compost (50%) + Inorganic fertilizer (APM 50%) + Dolomite	32	39
Significance	ns	ns
LSD (P=0.05)	-	-

No significant effect of treatments on nut yield in 2007 and 2008 (Table, 11).
The experiment is in progress.

S.H.S.Senarathne, K.C.P.Perera, H.B.Perera and I.M.Thilakerathna

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 (IL_1/S_5), 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.

T_1- Planting one row of Gliricidia at 1 m spacing (1275 trees ha^{-1})
T_2- Planting two rows of Gliricidia at 2 x 1 m spacing (2550 trees ha^{-1})
T_3- Planting two rows of Gliricidia at 1 x 1 m spacing (2550 trees ha^{-1})
T_4- Planting three rows of Gliricidia at 1 x 1 x 1 m spacing (3825 trees ha^{-1})

Treatments had significant effects on the wood and foliage biomass yield of Gliricidia after five years of planting (Table 12). The highest wood biomass was recorded in plots with three

rows of gliricidia (T_4) while the lowest was in plots with a single gliricidia row (T_1). However, plots with higher plant densities had a low wood and foliage biomass yield per tree (data not shown). Although treatments T_2 and T_3 had equal plant densities, the wider spacing gave higher wood and foliage biomass yields. However, this difference is not statistically significant. Treatment T_2 and T_3 are significantly different from treatment T_1 and T_4 in foliar biomass. Wood biomass production is significantly different only in treatment T_1 and the means of all other treatments are not significantly different.

Table 12: ***Wood and foliage biomass yield of gliricidia as affected by different planting densities at Ratmalagara Estate***

Treatment	Wood yield(kg ha^{-1})			Foliage biomass (kg ha^{-1})		
	2006	**2007**	**2008**	**2006**	**2007**	**2008**
T_1- One row (1275 trees/ha)	3 012	9975	2993	2 080	1323	157
T_2- Two rows (2550 trees/ha)	5 656	12760	11503	2 307	1845	508
T_3- Two rows (2550 trees/ha)	4 646	12974	9437	1 383	1971	406
T_4-Three rows (3825 trees/ha)	5 902	13552	12187	1 778	1764	762
Significance	*	*	*	n.s.	*	*
LSD (P=0.05)	2 139	4909	3919		361	174
CV%		24	27		13	24

The experiment is in progress.

H A J Gunathilake, H A Abeysoma and E M G Banda

Experiment 4.2: **Study of the effect of pruning height and planting spacing of Gliricidia to optimise the production of fuel wood and foliage biomass under coconut at Ratmalagara Estate (IL_1/S_5), 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 and pruning height on fuel wood and foliage biomass of Gliricidia.

T_1- Planting two rows of Gliricidia at 2 m x 1 m spacing and pruned at ground level
T_2 - Planting two rows of Gliricidia at 1 m x 1 m spacing and pruned at ground level
T_3 - Planting two rows of Gliricidia at 2 m x 1 m spacing and pruned at 45 cm above ground level
T_4- Planting two rows of Gliricidia at 1 m x 1 m spacing and pruned at 45 cm above ground level
T_5- Planting two rows of Gliricidia at 2 m x 1 m spacing and pruned at 90 cm above ground l5evel
T_6- Planting two rows of Gliricidia at 1 m x 1 m spacing and pruned at 90 cm above ground level

T_7- Planting two rows of Gliricidia at 2 m x 1 m spacing and pruned at 135 cm above ground level

T_8- Planting two rows of Gliricidia at 1m x 1 m spacing and pruned at 135 cm above ground level

Treatments had not significant effects on the wood and foliage biomass yield of Gliricidia after five years of planting (Table 13 & 14). The highest wood biomass was recorded in plots with two rows of Gliricidia at 2 m x 1 m spacing and pruned at 135 cm above ground level (T_7) while the lowest was in plots with two rows of Gliricidia at 1 m x 1 m spacing and pruned at 90 cm above ground level (T_6). However, the highest foliage biomass was found in plots with two rows of Gliricidia at 2 m x 1 m spacing and pruned at 45 cm above ground level (T_3) while the lowest was in plots with two rows of Gliricidia at 1 m x 1 m spacing and pruned at ground level (T_2) (Table 13 & 14).

Table 13: ***Wood biomass yield of gliricidia as affected by different planting densities and pruning heights at Ratmalagara Estate***

Treatments	Wood yield (dry) kg per plant				
	2004	**2005**	**2006**	**2007**	**2008**
T_1	1.09	2.20	5.16	3.89	6.90
T_2	0.51	1.57	4.77	3.56	5.52
T_3	0.77	2.23	3.75	3.39	7.18
T_4	1.28	2.76	3.68	3.59	5.61
T_5	1.20	3.07	3.30	4.69	6.19
T_6	0.83	2.51	4.67	5.43	4.53
T_7	0.87	2.18	4.04	4.72	8.57
T_8	0.74	1.77	4.82	4.86	6.86
Significance LSD (P=0.05)	n.s. -	n.s. -	n.s. -	n.s. -	n.s. -

Table 14: ***Foliage biomass yield of gliricidia as affected by different planting densities and pruning heights at Ratmalagara Estate***

Treatments	Dry foliage biomass (kg /plant)				
	2004	**2005**	**2006**	**2007**	**2008**
T_1	0.30	0.45	0.31	0.38	0.50
T_2	0.23	0.33	0.30	0.40	0.29
T_3	0.26	0.39	0.45	0.39	0.85
T_4	0.34	0.48	0.30	0.45	0.44
T_5	0.30	0.40	0.47	0.54	0.54
T_6	0.27	0.38	0.45	0.49	0.73
T_7	0.26	0.36	0.57	0.38	0.39
T_8	0.27	0.37	0.38	0.48	0.67
Significance LSD (P=0.05)	n.s. -	n.s. -	n.s. -	n.s. -	n.s. -

The experiment is in progress.

H A J Gunathilake, H A Abeysoma and E M G Banda

Experiment 4.3: Development of Gliricidia as a multipurpose tree for generation of Bio – Energy and Bio-Fertilizer – Rathmalagara Estate, 2006

Alone with the price increases of fossil fuel and electricity, there is also an increased realization in the country that traditional energy is going to be more expensive with time. Hence development of alternative energy production systems within the plantation/ agriculture sector is vital for national energy security and sustainable agricultural production.

The objectives of this experiment were to maximize farm income though an integrated (Coconut / Giliricidia/ Paddy straw/ Cattle) farming system and to develop a sustainable Bio-Energy system to meet energy requirement in coconut plantations.

One hectare of Coconut land was selected to establish this farming model. The model consisted with coconut (156 palms ha^{-1}) double of giliricidia planted in to 1.0m x 1.0 m spacing. (2250 tree ha^{-1}) , six female butt aloes feeding paddy strew, natural pasture, gliricidia fodder cattle dung were directed to a bio gas generator for biogas production. Biogas was utilized by a 0.75 hp generator.

During the year coconut palms produced 82 nuts/ palm / year in model area Compared to 49 nuts $palm^{-1}year^{-1}$ in rear of the estate. Fire female butt aloes calved 4 male and 2 female calves. Average milk production was 558 l / animal during theirs 2^{nd} lactation period predicting of giliricidia was 8 kg of foliage and 6.0 kg of wood $tree^{-1}$ $year^{-1}$. Biogas was enough to run 0.75 hp generator for 3 hours day^{-1}. Total gross return of the model was Rs. 0.978 million for this year. Of this, value of energy contributed 53% of the total income.

The experiment is in progress

H.A.J. Gunathilaka and H.A. Abeysoma.

PROJECT 5: ORGANIC COCONUT FARMING

Experiment 5.1: Effect of different sources of organic manure applications on the performance of mature coconut palms at Ratmalagara Estate (IL_1/S_5), 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. Age of the palms was 55 years and planted at a spacing of 8.5 m X 8.5 m.

Treatments:

T_1 - Application of 3 kg of APM + 1 kg of Dolomite

T_2 - Application of 50 kg of Gliricidia + 230 coconut husks + 600 g of ERP + 1 kg of Dolomite

T_3 - Application of 25 kg of goat manure + 130 coconut husks + 600 g of ERP + 1 kg of Dolomite

T_4 - Application of 30 kg of Gliricidia + 230 coconut husks + 600 g of ERP + 1 kg of Dolomite + Puraria cover crop

Table 15: ***Effect of different organic manure applications on coconut yield at Ratmalagara Estate***

Treatments	Coconut Yield (nuts palm^{-1} year^{-1})				
	2004	2005	2006	2007	2008
T_1	63	74	86	65	89
T_2	79	55	85	57	81
T_3	51	75	104	65	88
T_4	62	60	79	58	84

Generally, coconut yield of year 2008 showed considerable increase compared to the same in year 2007. There was no difference in nut yield among the treatments T_1 – T_3. However palms treated with goat manure supplemented with other organic and natural mineral sources T_3 and Adult Palm Mixture (APM) (T_1) showed higher nut yield than Gliricidia (T_2 and T_4) treatments (Table, 15). This indicates that as a source of organic N, goat manure is seems the

beneficial over Gliricidia and application of APM may be the added advantage over Gliricidia. However, Gliricidia is cheaply available as in-situ N source in coconut lands.

Table 16: ***Effect of different organic manure applications on soil bulk density of manure circle at Ratmalagara Estate***

Treatments	Bulk density of manure circle g/cm^3
T_1	1.58 a
T_2	1.23 c
T_3	1.39 b
T_4	1.36 b
Significance	*
LSD	0.06

According to the table 16, T_1 shows the significantly highest bulk density than other treatments. It illustrates that organic manuring practices increase the soil porosity and loose the soil structure compared with chemical manuring practices.

The experiment is in progress.

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H A Abeysoma and W A Hemawardena

Experiment 5.2: Effect of organic manure application on the performance of T x T coconut seedlings at Pallama Seed Garden (IL_1/S_4)-2006

The experiment was designed to evaluate the prospects and constraints of raising coconut seedlings using 100% organic inputs. Treatments 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 mentioned in Table 17.

Treatments: T_1-Control (YPM + 1000 g of Dolomite)
T_2-Vermicompost (5 kg + 200 g of ERP + 250 g of Dolomite)
T_3-Gliricidia (5 kg + 275 g of ERP + 250 g of Dolomite)
T_4-Cattle or Goat manure (5 kg + 200 g of ERP + 250 g of Dolomite)

Table 17: *Different treatment application plan of the experiment at Pallama Seed Garden*

Treatments	Ingredients	Basal	Age of the Plantation (Years)							
			0.5	1	1.5	2	2.5	3	3.5	4
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 18: *Effect of different treatments on growth performance of T x T coconut seedlings at Pallama Seed Garden*

Treatments	Leaf production (no of leaves per year)			Seedling girth (cm)		
	2006	2007	2008	2006	2007	2008
T_1	7	8	8	27	33	48.7
T_2	6	7	8	29	32	45.6
T_3	7	7	8	26	31	43.8
T_4	7	7	8	26	30	48.6
Significance	ns	ns	ns	ns	ns	ns
L.S.D (P=0.05)	-	-	-	-	-	-

During the year, number of leaves per palm and basal girth of the palm have not shown any significant difference among treatments. This indicates that, vermicompost, Gliricidia and goat manure are also equilent to application of Young Palm Mixture so far.

Experiment is in progress.

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

Experiment 5.3: Development of green manure based fertilizer mixture for organic coconut farming systems

Experiment 5.3.1: Evaluation of growth performance of *Tithonia diversifolia* under coconut plantations in different agro-climatic zones.

Experiment a: Pothukulama Estate (IL_1/S_4)

Experiment b: Walpita Estate (IL_1/S_4)-2008

The objective of this experiment was to study the effect of different environmental conditions on growth of *Tithonia diversifolia* in coconut plantations. *Tithonia*, commonly known as Mexican sunflower, is a shrub belonging to the family Asteraceae. The biomass of *Tithonia* used for soil fertility improvement generally includes both green tender stems and leaves but not woody stems. The biomass nutrient content (4%-N, 0.56%-P and 4.8% - K) of *Tithonia*, as compared to green biomass of other shrubs and trees, is relatively high in Potassium.

Therefore, two experiments were established at Pothukulama and Walpita estates, using following treatments on a Randomized Complete Block Design with four replicates..

Treatments: Different pruning intervals

T_1 – Three months interval (4 times per year)

T_2 - Four months interval (3 times per year)

T_3 - Six months interval (2 times per year)

Biomass production and different soil properties were measured.

The experiment is in progress.

S H S Senarathne, K C P Perera, M.J.I.Costa, B Perera and R. Suwarnathilake

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

Experiment 6.1: Effect of glyphosate on root growth of coconut seedlings.

The objective of this experiment was to study the effect of different concentration of glyphosate on root growth of coconut seedlings. Application of glyphosate is the very cost effectiveness method to control weeds in coconut nurseries. However, some research information showed that glyphosate blocked the plant physiological enzyme activities and inhibited the plant root development process. Thus, no research had been carried out on glyphosate to understand its activity on root growth performances in coconut seedlings.

Therefore one experiment was established in Bandirippuwa Estate (as a plant house experiment) using following treatments on a Randomized Complete Block Design with three replicates (10 coconut seedlings per treatment).

Treatments: Different concentrations of glyphosate

T_1. Application of glyphosate 4 liters per hectare (1.44 ai kg /ha)
T_2. Application of glyphosate 3 liters per hectare (0.81 ai kg /ha)
T_3. Control (no glyphosate)

Coconut seedling shoot and root growth parameters are being measured.

The experiment is in progress.

S H S Senarathne, K C P Perera, M.J.I.Costa

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

a. Rathmalagara Estate, Madampe (IL_1/S_4) - 1995

Treatments given in Table 19 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 19). Grafted cashew reached early flowering and yielded within two years of planting followed by air-layered cashew plants. At the age of seven, both vegetative propagated cashew produced cashew yield of over 5.0 kg $tree^{-1}year^{-1}$. Cashew propagated with seeds took more than five years to flower, but from the 7^{th} 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.

Table 19: *The effect of the plant type of cashew on coconut yield at Rathmalagara Estate*

Treatments	Coconut yield (nuts palm^{-1}year^{-1})				
	2004	2005	2006	2007	2008
T_1-Coconut monoculture	79	50	80	70	70
T_2-Bud grafted cashew	75	51	70	77	56
T_3-Air-layered cashew	70	40	78	79	61
T_4-Seedling cashew	67	51	74	62	70
Significance (P=0.05)	n.s.	n.s.	n.s.	n.s.	ns

The experiment is in progress.

H A J Gunathilake, H A Abeysoma and W. A.H emawardane

b. Pallama Seed Garden (IL_1/S_4) - 2000

Intercropping with cashew did not show any significant effect on coconut yield as observed in the previous year (Table 20). There was significant effect of treatments on copra yield and the highest value was given by bud grafted cashew plots. At Pallama site, cashew yields were not taken because of severe pest damage.

Table 20: *Coconut yield as affected by intercropping with three different types of planting materials of Cashew at Pallama Seed Garden*

Treatments	Coconut yield (nuts palm^{-1}year^{-1})					Copra yield (kg palm^{-1}year^{-1})
	2004	2005	2006	2007	2008	2008
T_1-Coconut monoculture	66	51	79	66	50	11.63
T_2-Bud grafted cashew	72	64	93	80	67	18.16
T_3-Air-layered cashew	68	61	92	75	64	15.22
T_4-Seedling cashew	69	58	90	71	60	14.82
Significance	n.s.	n.s.	n.s	*	n.s.	*
L.S.D.(P=0.05)				12		5.08

c. Girtland Estate (IL_1/S_4) - 2008

Cashew growing other countries yield over 10.0 kg tree^{-1}, however local yield limits to 5.0-6.0 kg tree^{-1} year^{-1}. Yield of cashew would be improved by evaluating high yielding varieties and but grafting. Sri Lanka Cashew Cooperation and University of Wayambe together experimented on developing high yielding varieties and as a result, joint research programme

of them has released several varieties under the code of "WUCC". Three of them, namely WUCC -5, WUCC- 8 and WUCC -13 selected for evaluation under coconut in the Intermediate Zone for high yield while no/ less competitive with coconuts. But grafted casher plants were planted in centre of coconut square in alternative rows giving half the plant density of coconut (78 trees ha^{-1}) Nut yield of coconuts is being recorded (Table 21). So far cashew did not reach flowering.

Table 21: ***The effect of different cashew varieties on coconut yield at Girtland Estate in 2008***

Treatments	Coconut yield (nuts $palm^{-1}year^{-1}$)
T_1 – WUCC 5	42
T_2 – WUCC 8	35
T_3 – WUCC 13	33
Significance (P=0.05)	ns
LSD (P=0.05)	-

The experiments are in progress.

H A J Gunathilake, A Gunasekera and B Perera

Experiment 7.2: **Inter cultivation high demanding foliage plant species (Areca lutescens, Cordyline Fruiticosa Red, Livistonia) under coconut in the low country wet zone. Molawatta Estate, Udugampola (WL3/S3) -2007**

In recent years, much interest has been focused in the diversification of coconut lands for integrated tree farming on floriculture in the wet zone. Among the intercrops, ornamental foliage plant varieties are well adapted to the wet zone. However, information on the feasibility of inter cultivation foliage plants with coconut is scarce.

The above study was initiated in October 2007 to determine a suitable cut foliage plant varieties for inter cultivating with mature coconut in the low country wet zone. The foliage plant varieties were chosen on the basis of market potential and adaptability to the agro-ecological zone and cultivated in between coconut rows.

The experiment was arranged in a Randomized Complete Block design with three replicates. Each experimental plot was consisted with 6 effective palms. Nut yield and growth performance of different foliage species were measured.

Treatments :
T_1- Areca lutescens (Cane palm)
T_2- Cordyline spp
T_3- Livistonia spp (Queen palm)
T_4- Control

Table 22: *Effect of different treatments on coconut yield at Molawatta Estate, Udugampola in 2008*

Treatments	Nut yield (nuts palm^{-1}year^{-1})
T_1-Arica lutesence	26
T_2-Cordyline spp	26
T_3-Livistona spp	22
T_4-Controll	23
Significance	n.s.
LSD (P=0.05)	-

In year 2008, the nut yield did not differ among treatments. It shows that, there was no any negative effect on coconut plantation of inter-cultivation of above foliage plant species (Table 22).

Table 23: *Growth performances of inter-cultivated foliage plants at Molawatta Estate, Udugampola in 2008*

Foliage species	Time to reach production stage (days)	Leaf Production Rate (leaves plant^{-1}year^{-1})
T_1-Arica lutesence	365	09
T_2-Cordyline spp	100	40
T_3-Livistona spp	300	09

Cordyline is the early and quick leaf producer and it shows the better performance than Arica lutesence and Livistona spp (Table, 23).

The experiment is in progress.

B A S Manjula, K C P Perera, W R O Fernando

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

Experiment 8.1 **Cultivation of Coimbatoor 3 (CO-3) fodder under coconut to improve the productivity of coconut lands at Bandirippuwa Estate (IL1/ S4)**

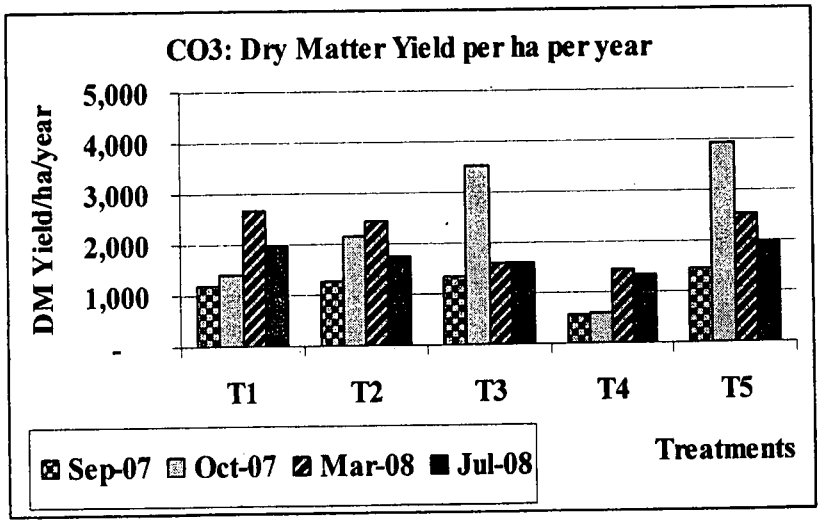
Application of treatments was commenced in maha season in December 2007.

Soil samples were collected in mid 2008 but, could not be analysed due to staff shortage at the division. Table 24 shows the average nut yield per palm per year per treatment. This increase in nut yield may be due to the agronomic practises such as harrowing, slashing, organic manure application etc carried out in the field. During the year CO3 bushes were pruned and treatments were applied twice, in March and July 2008. Table 25 shows the Dry Matter Yield per ha per year but the results could not be analysed as establishment of CO3 in blocks 2 & 3 was completed only in July 2008.

Table 24: ***Average nut yield per palm per year***

Treatment	2006	2007	2008
T_1- Control (0kg of Urea/ha)	18	50	61
T_2- 30 kg of Urea/ha/year	16	57	67
T_3- 45 kg of Urea/ha/year	18	54	66
T_4- 60 kg of Urea/ha/year	15	51	75
T_5- 75 kg of Urea/ha/year	16	61	68

Table 25: ***CO3: Dry Matter Yield per ha per year***



The experiment is in progress.

S.C.Somasiri, M.D.V.Saparamadu, W.S.M.A. Fernando and E.M.Gunaratne Banda

Demonstration 8:1. Development of smallholder sheep farming system to increase the productivity of Coconut lands Bandirippuwa Estate. (IL1/ S4)

One cycle of grazing (6 months) was completed during the year. Dry matter percentages at the starting and end of the cycle were 28% and 20% respectively. Average body weight of Ewes and Ram at the beginning of the grazing cycle was 25 kg. Lambing rate during the year was 89%. Male to female ratio of lambs was 1:1. One lamb died after 6 hours of birth because of poor health. Soil samples could not be analysed due to staff shortage at the division.

Total nut yield for 2008 was 3,539 nut/acre, 23% increase compared to year 2007.

It was observed that Red Madras and Bickerney breeds were well adapted for rearing under coconut. They were treated against *fluxes, tape worms* and *central nervous system* disease. Routine de worming treatments were also carried out. Flock was allowed to graze after 9 o'clock in the morning and they were fed with mineral mixture at a rate of one tea spoon per adult per day. At night flock was housed in a slated house.

This unit will be maintained as a Sheep Breeding/Demonstration unit under coconut here after.

S.C.Somasiri, M.D.V.Saparamadu, W.S.M.A. Fernando and Y.M.Chandrasiri

3. RESEARCH PROJECTS FUNDED BY OUTSIDE AGENCIES

Experiment 3.1 Preservation of low cost feed to overcome the scarcity of feeds during dry season at Ratmalagara Estate, (IL_1/S_5), Madampe - 2006 – (National Science Foundation) Project

Pasture and fodder production during rainy season is comparatively high in coconut triangle therefore, excess feed can be harvested and preserved for the dry season to maintain a uniform livestock production through out the year. Forage can be preserved in the form of leaf meals, hay, silage and feed blocks. Leguminous leaf meals are an alternative feed source for livestock during these dry seasons. Leaf meals can be pressed into blocks/briquettes with or without incorporating other concentrate feed ingredients such as coconut poonac, rice polish/bran and molasses so that keeping quality can be increased and a market value can be obtained. Therefore, a research was carried out with an objective to develop a leguminous leaf meal (LM) block as an animal feed.

This research was funded by The National Science Foundation. Total research grant allocation was Rs 2,696,006.00 for the period of 2006/2009. This research was carried out at Coconut Research Institute in collaboration with the Postgraduate Institute of Agriculture, University of Peradeniya and Veterinary Research Institute, Gannoruwa.
The Tender for the Briquette Machine was awarded to CRISTO Industries, Demanhandiya. Briquettes of 500 g were prepared according to nine leaf meal recipes using the 4 leaf meals *Gliricidie sepium* (Gliricidia), *Leucaeana leucosephela* (Ipil Ipil), *Calliandra calothyrous* (Calliandra) and *Acacia mangium* (Acacia) to Complete Randomized Design with 6 replicates. Preparation of briquettes were successful from the recipes prepared using

Gliricidia sepium, Leucaena leucocephala and *Calliandra calothyrus* leaf meals. Briquettes prepared from *Acacia mangium* leaf meal recipes were not in compact form. These blocks were stored for three months. Each month two blocks would be broken and analyzed for Total Plate Count and Free Fatty Acid content to determine the shelf life. The best leaf meal and the recipe would be selected and a feeding trial would be carried out in the year 2009 to test the palatability and animal performances.

The following Tables show the height and girth measurements of the Nitrogen Fixing Tree (NFT) species block established at Ratmalagara Estate, (IL_1/S_5), Madampe.

Table 26: ***Measurement of height (cm): NFT species block at Ratmalagara Estate***

Nitrogen Fixing Tree	Height (cm)			
	February	May	August	December
Acacia spp	23.2	96.0	154.9	216.4
Gliricidia sepium	23.2	66.2	84.8	105.8
Calliandra calothyrsus	19.1	56.7	112.4	159.8
Leucaena leucocephala	29.4	54.8	62.1	65.8

Table 27: ***Measurement of girth (mm): NFT species block at Ratmalagara Estate***

Nitrogen Fixing Tree	Girth (mm)			
	February	May	August	December
Acacia spp	7.2	21.7	37.3	57.2
Gliricidia sepium	11.6	25.3	35.5	41.9
Calliandra calothyrsus	9.1	15.4	26.5	38.8
Leucaena leucocephala	9.8	17.9	22.8	26.3

According to the above tables *Acacia spp* has a significantly higher growth compared to the other 3 species.

Table 28: ***Total nut yield records: NFT species block at Ratmalagara Estate***

Nitrogen Fixing Tree	Total nut yield 2008 (nuts)
Acacia spp	841
Gliricidia sepium	794
Calliandra calothyrsus	1058
Leucaena leucocephala	1291

Note: per treatment there were 16 palms.

Total nut yield of the blocks established with *Leucaena leucocephala was higher than the other three species.*
This experiment is in progress.

S.C.Somasiri, Sujatha Premarathne, H.A.J.Gunathilake, H.A.Abeysoma, M.D.V.Saparamadu, Y.M.Chandrasiri and J.H.M.Nadun Sathsara*
**Faculty of Agriculture, University of Peradeniya*

4. SELF-FINANCED PROJECTS

4.1: Fuel wood plantation project - Pallama Seed Garden, 1998 (IL_1/S_5)

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 S_4 and S_5 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 32,000 and 5,000 Gliricidia and Acacia trees respectively. The total marketable wood yield has increased by only about 2% compared to the previous year. However, the increase in net profit is about 90% compared to the previous year mainly due to the reduction in total expenditure related to maintenance and operation of the plantation.

The project is in progress.

H A J Gunathilake, A Gunesekera and K D D Appuhamy

5. MISCELLANEOUS STUDIES

5.1: Demonstration farm, Thabbowa, Nattandiya

The farm, which consists of 2.5 ha is being managed on 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.

Table 29: ***Annual income and expenditure of demonstration farm, Thabbowa***

Income			**Expenditure**	
Item	**Quantity Nuts/Seedlings**	**Value Rs.**	**Item**	**Value Rs.**
a. Sale of coconut	33015	784,832.00	a. Labour	488,901.43
b. Sale of coconut seedlings			b. Others	142,041.45
Poly bagged T x T			c. Electricity	32,048.00
D x T	1040	104,000.00	d. Seed nuts	300,080.00
R.D	147	11,760.00	e. Poly bags	69,000.00
K.C	56	5,600.00	f. Filling bags	14,192.00
	20	2,000.00		
Bare rooted T x T				
D x T	602	30,100.00		
	414	12,480.00		
c. Sale of other crops		59,596.08		
Total Income		**1,134,888.08**		**1,046,262.88**
Profit:		**88,625.20**		

The farm had a net profit of Rs. 88,625.20 in year 2008 (Table 29).
The project is in progress.

H A J Gunathilake, S.H.S.Senarathne and P Fernando

5.2: Animal breeding program at Maduruoya Seed Garden and Potthukulama Research Station

The animal-breeding programme at Maduruoya and Potthukulama are being continued to develop the animal husbandry sector in coconut plantations, an animal breeding project was started in 1999 to develop a smallholder goat and buffalo farming systems under coconut with the objective of increasing the profitability and fertility in coconut lands. The number of male and female heads remained at each site at the end of the year are given below (Table 30). Thirty male and female goats were sold to coconut growers to initiate the goat farming units in their estates and net profit of this project was Rs. 3, 54,610.30 in year 2008.

Table 30: ***Animal breeding program at Maduruoya Seed Garden and Potthukulama Research Station in 2008***

Location	Breed	Adults		Calves		Total	
		F	M	F	M	F	M
Maduruoya S.G.	Moora	22	12	09	04	31	16
Potthukulama.R.S	SriLankan Boer	30	14	19	09	49	23

The project is in progress.

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 S_1 lands (S_1/IL1) Bandirippuwa Estate

Different cultural practices were imposed on coconut (Dwarf x Tall) grown in S_1 lands to demonstrate importance of them for 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 140 nuts palm^{-1}year^{-1} mainly due to high suitability of soil (Table, 31). Coconut palms responded well to weed control and moisture conservation which yielded 143 nuts palm^{-1}year^{-1}. The difference between fertilizer application vs no fertilizer was 36 nuts palm^{-1}year^{-1} (Table, 31). A response for soil moisture conservation practices was not seen due to performance in S_1 lands.

Treatments:

T_1 – No management
T_2 – Weed control only
T_3 – Weed control + moisture conservation only
T_4 – Weed control + fertilizer application
T_5 - Weed control + fertilizer application + moisture conservation
T_6 - Weed control + fertilizer application + moisture conservation + cover crop
T_7 - Weed control + moisture conservation + green manure (Gliricidia) + Supplementary inorganic fertilizer
T_8 - Weed control + fertilizer application + moisture conservation + supplementary organic fertilizer

Table 31: ***Nut yield as affected by different management systems in coconut plantations***

Treatments	Mean yield	Nut yield (nuts palm^{-1} year^{-1})		
	(2001 – 2005)	2006	2007	2008
T_1	110	120	72	80
T_2	104	125	77	143
T_3	94	119	86	143
T_4	116	164	127	116
T_5	95	137	67	141
T_6	111	151	115	98
T_7	119	184	134	135
T_8	101	143	99	120

H A J Gunathilake and K D D Appuhamy

6.2: Development and popularization of organic coconut production and processing in Sri Lanka -2005

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

During the year, seven sites had to be abandoned due to failures of farmers. Out of the twenty two models Boyawalana, Wariyapola, Kobbewehera, Hangamuwa, Holagamuwawatta, Kattambuwawa and Polpitigama sites were provided with seven neat cattle to improve the organic manuring system. Establishment of the Bio Gas Production System has been completed at Uggalboda model site and entire domestic liquid petroleum (LP) gas consumption have been replaced by bio gas. After establishment of this system each coconut palm are fertilized with 300 litres of digested slurry which is by-product of bio gas production unit and 180 coconut husks.

Likewise, buffalo farming and goat farming are being successfully carried out at Watuwatta model site and curd and organic compost production projects are also successfully being carried out. Further that, initial steps are being taken to establish a bio gas production unit at the site.

All the twenty two model site are being functioned according to the organic farming guidelines and Ridigama, Walpitagama, Kobbewehera, Kattambuwawa and Polpitigama sites have been certified as organic lands. Certification costs were bared by Cerandipol and Lanka Organics Pvt Ltds. During the year four training programmes for model farmers were conducted at Boyawalana, Thisogama and Polpitigama model sites.

Table 32: ***Establishment of different organic model farms in coconut triangle***

Name of the grower	Location of the model
1. Mr M S Tennakoon	Dalupothawatta, Madawa, Pilassa
2. Mr A R S Anwar	Mallawapitiya, Kurunegala
3. Mr J A D K Jayasinghe	Gunawil, Bandawa, Polgahawela
4. Mr N Wijenayake	Ridiuyanwatta Estate, Ridigama
5. Mr K H S Kumarasinghe	Sarasavi Integrated Farm, Dummalasuriya
6. Mr S Kaluarachchi	Boyawalana, Keppitiwalana
7. Mr Wikrama Rodrigoo	Wadumunegedara, Walpitagama
8. Mr Susantha Hapuarachchi	235, Puttalam Rd, Wariyapola
9. Mrs M S M de Silva	105 Hapitigama, Kal Eliya
10. Mr R S Athulathmudali	Raiyadoluwa Estate, Uggalboda, Gampaha
11. Mr C P de Silva Jayaratne	Madampe Estate, Madampe
12. Mr Ervan Perera	Kandawatta, Block 2, Mugunuwtawana
13. Mr G D Gunawardena	Dekinda Estate, Madawalaulpatha
14. Mr S S W Kumarasinghe	Horagalawatta, Horagala
15. Mr A K Upali Amarasinghe	Kobbevehera, Mahamukalanyaya
16. Mr K A Jayarathne	Hangamuwa, Ibbagamuwa
17. Mr Paulu Perera	Tharuna Govipola, Thisogama
18. Mr R Wimalasena	Holagamuwawatta, Holagamuwa, Narammala
19. Mr M M Podiappuhami	Thoranegedara, Kirimetiyawa
20. Mrs G R Chandrawathi	Kandegedara, Maharachchimulla
21. Mr W M Dissanayake	Diyatambe, Kattambuwawa, Koonwewa
22. Mr D M Kapurubanda	Thalakolawewa, Polpithigama

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

The project is in progress

B A S Manjula, R Marasighe, W R O Fernando,
K D D Appuhamy, S Warnakula

7. ACKNOWLEDGEMENT

The cooperation extended by the staff of the Agronomy Division for carrying out the Divisional Research Program is greatly appreciated. The continued support of Dr A. Thennakoon, and the staff of the Soils and Plant Nutrition Division for analysing soil samples are gratefully acknowledged.

Staff Matters

Academic and Professional Achievements

Dr. H.A.J. Gunathilaka awarded, National Science and Technology Awards, 2008 of National Science foundation. The theme was "Giricidia as a fuel crop com and Substitute for Fodder and Fertilizer", under category of development of eco- materials / eco– friendly processes for industry. The others were Vidya Jothi Dr. Ray Wijewardana, P.G. Joseph and Parakrame Jayasinhe.

University student supervision

Dr. S.H.S.Senarathne supervised the final year research project of Miss. R.D.V. Fernando, a final year student of the Faculty of Agriculture, University of Peradeniya. The title of the project was the Allelopathic Effects of *Lantana camara* on Tomato (*Lycopersicum esculentum*) and Yard Long Bean (*Vigna cylindrical*).

Dr. S.H.S.Senarathne supervised the final year research project of Mr. B.G.P.S.K. Wijebandara, a final year student of the Faculty of Agriculture, University of Peradeniya. The title of the project was the Evaluation of Quality of Vermicompost Produced Using Different Weed Species.

Training and Extension Activities

All staff members of the division actively participated in the One Day Training Programs on soil moisture conservation, rehabilitation of low yielding coconut plantations, intercropping and estate management.

ANNUAL REPORT OF THE GENETICS AND PLANT BREEDING DIVISION

Head - Lalith Perera, PhD (Scotland)

Summary

Planting of four multi-locational trials and two observational trails with exotic crosses was the major achievement of the Genetics and Plant Breeding Division during the year 2008. A new crossing programme to produce San Ramon x Dwarf Brown and Tall x Dwarf Brown was also commenced this year to plant them in the farmers' fields as adaptive trials to complement the research fields planted with the reciprocal of these crosses in multi-locations. The evaluation of existing cultivars, evaluation of progenies, evaluation of new coconut cultivars in farmers' fields (adaptive trials), evaluation of Dwarf Brown crosses in multi-locations, development of coconut cultivars tolerant to *Aceria* mite, development of Dwarf x Dwarf crosses, maintenance and expansion of existing gene banks and coconut genome mapping were continued successfully during the year. The genotyping of the new coconut varieties identified in the Unawatuna area and, determination of marker polymorphism between the parents of the mapping population were the major achievements in the molecular biology activities of the division this year. Under the development and service functions of the division, certification of 384,838 polybagged seedlings, identification of seven new plus palm estates with 8173 plus palms, field establishment of 2034 seedlings at Pallama Seed Garden (PSG), continuation of the self pollination of variety San Ramon (SR) at Pottukulama Research Station (PRS) and at PSG for production of planting materials for further expansion of PSG, production of CRISL98 and Kapruwana seed nuts by hand pollination programme both at ISG and PSG for commercial issue were noteworthy to be mentioned. Conducting a national training programme on "Application of molecular markers in plants and pathogens' sponsored by the FAO and CARP and conducted by the Genetics & Plant Breeding division staff at CRI was another noteworthy accomplishment during the year.

The main accomplishment of the year was the planting of four multi-locational trials with exotic crosses (Sri Lanka Tall x Rennel Island Tall, Sri Lanka Tall x Tagnanan Tall, Sri Lanka Tall x Malaysian Red Dwarf, Sri Lanka Green Dwarf x Rennel Island Tall, Sri Lanka Green Dwarf x Tagnanan Tall, Sri Lanka Tall x Brazilian Green Dwarf as new crosses and CRIC65, CRISL98 and Kapruwana as check varieties) in various combinations in different sites. The sites planted during the year were Marandawila farm, Beligama farm, Middeniya estate and Sringapatha farm representing Dry Intermediate, Dry Intermediate, Dry and wet zone respectively. In addition two large observational blocks were also planted at PRS and Wanathawilluwa representing Dry intermediate and Dry zones respectively. The pollination programme to produce more seeds from various exotic crosses continued at ISG and PSG during this year too for establishment of more research and observational trials.

During the year, the experiment at the site Suriyapura (SE) for Evaluation of existing coconut cultivars trial had to be abandoned as a result of land fragmentation and hence this project was continued only with the experimental site at Bandirippuwa (BE) for further data collection. Yield recording was carried out in ten picks at BE during the year and similar to previous years the two hybrids, Green Dwarf x Tall (GDT) and Yellow Dwarf x Tall (YDT) continued to outperform three tall cultivars Tall x Tall (TT or CRIC60), Plus Palm Tall (PPT) and Moorock Tall (MT) under average management conditions with total annual yield of 16,499 nuts/ha and 14,502 nuts/ha respectively this year.

During the year nut yield was recorded at progeny trials at BE, Rathmalagara Estate (RE) and Andigama (Mudalihamy) sites while nut yield recording and fruit component studies were carried out in other three sites at Andigama (Puras), Sirikandura and Daisy Valley (DV). The nut yield in decreasing order in general was Tall x Green Dwarf (T x GD), Green Dwarf x Tall (GD x T), Green Dwarf x San Ramon (GD x SR), Tall x Tall (T x T) and Tall x San Ramon (T x SR or CRISL98) at BE, RE and DV. However, the superiority of T x GD as a nut producer was not to be seen at marginal sites for coconut cultivation at Mudalihamy and Sirikandura sites. As in the previous years, this year too the T x SR outperformed all other crosses with respect to fruit components in all the sites evaluated.

The evaluation of Brown Dwarf crosses at Raddegoda, RE, Wanathawilluwa and BE maintained satisfactorily. Growth measurements and flowering data were recorded at Raddegoda, RE and Wanathawilluwa at six monthly intervals. A pollination programme was commenced in January to produce Tall x Brown Dwarf and San Ramon x Brown Dwarf seedlings to plant in farmer fields as adaptive trials. Twenty seven San Ramon palms and sixteen tall palms were selected from Margaret estate, Pallama and was crossed with brown dwarf pollen collected from PRS. During the year fruit component data of the natural hybrids of Brown Dwarf x Tall planted at PRS was recorded in six picks. The data analysis revealed that in contrast to other hybrid forms the fruit components; fresh weight, husked nut weight, split nut weight, kernel weight, weight of coconut water and shell weight, were significantly greater in natural hybrids of Brown Dwarf x Tall than CRIC60 except for the weight of husk.

The crossing programme involving local varieties (Sri Lanka Tall, Sri Lanka Green Dwarf, Gon Thembili and Sri Lanka Yellow Dwarf) and a few exotic varieties (Brazilian Green Dwarf and San Ramon) towards developing *Aceria* mite tolerant coconut cultivars with hybrid vigour for yield continued during 2008. Two thousand six hundred and sixty eight hand pollinated seednuts of the above crosses were collected and nursery laid. Seedlings of the cross Sri Lanka Tall x Brazilian Green Dwarf were field planted in multi-locational trials along with the exotic crosses.

The Dwarf x Dwarf crossing programme commenced at the end of 2007 successfully continued this year resulting 1033 setting of buttons to 31 September 2008.

Pollination programme for production of CRISL98 and Kapruwana was successfully continued this year too at ISG producing 9157 CRISL98 seeds and 3832 Kapruwana seeds. The TSR pollination programme commenced at PSG last year yielded 2508 CRISL98 seed nuts. The TSR pollination programme at ISG was terminated this year and further 50 tall palms at PSG was included in the CRISL98 seed production programme confining the CRISL98 seed production only to PSG. Total of 22 farmer fields comprising 15 CRISL98 and 07 Kapruwana sites were established during the year in 6 districts.

During the year the mapping population planted at Walpita was maintained successfully. The Genotype Supporting Service of the GCP extended their support to genotype the mapping population with another 50 SSR primers making the total number of primers to be used for genotyping 75. The genotyping of the parents; Red Dwarf and Sri Lanka Tall, was completed by the year end and 120 markers were observed to be polymorphic between parents. However, only 40 markers were found to segregate in the mapping population limiting the number of informative markers to 40. The hand pollination programme for crossing *Aceria* mite tolerant

Yellow Dwarf palms with pollen from a highly susceptible Sri Lanka Tall palm resulted in a total of 995 seedlings.

Three hundred and seventeen seedlings from the Unawatuna germplasm collection was planted at the Margaret estate by the end of the year under germplasm conservation programme. All field gene banks were successfully maintained during the year, except for Margaret estate new genebank where some seedlings succumbed to elephant damage.

During the year, seven new coconut estates were designated as Plus Palm estates for the supply of seed nuts for the National Replanting Programme and 8173 new palms were selected from them.

The pollination programme for selfing San Ramon at PRS and PSG continued and as a result 1104 self pollinated san ramon seed nuts were harvested and nursery laid. During the year 434 self pollinated SR seedlings in guard rows and 1600 Tall x Tall seedlings at field number 4 of PSG field planted under the seed garden establishment programme. Two thousand open pollinated Green Dwarf seed nuts were collected during the year and was nursery laid at ISG to be used in establishing the proposed new seed garden for Kapruwana next year. This work will be carried out next year.

Detailed Report

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

Locations and agro-climatic conditions

Exp. Number	Location	Year established	Soil type	Agro-ecological zone
12.1.1	Bandirippuwa (BE)	1983	Loamy sand (S2)	Wet intermediate
12.1.2	Thammenna (TE)	1983	Latasol (S2)	Dry
12.1.3	Palugaswewa (PE)	1985	Sandy clay loam	Dry intermediate
12.1.4	Suriyapura (SE)	1986	Lateritic-gravel/clayey (S4)	Wet

The nut yield data and kenal weight data pertaining to this project was thoroughly analysed during the year and the results were presented at the "Second Plantation Crop Symposium" held at BMICH in this year (Dissanayaka H D M A C *et al.*, 2008). The results were summarized as follows.

Precocity was notably varied between the hybrids and the tall cultivars at both BE and SE sites revealing that hybrids are more precocious than any of the tall cultivars (Table 1). The

mean flowering time of the two hybrids over the two sites was 57 months compared to 78 months of all the tall cultivars and the difference is approximately two years.

At BE the mean time taken for first flowering was not statistically different between two hybrids. However the time difference between GDT and YDT was significant at SE, GDT being 9 months early in flower initiation at SE indicating a genotype x environment interaction for flowering time. Generally both hybrids initiate flowering around four years after planting and nearly 75% of palms initiate flowering before the 5th year. On the contrary the time taken for flower initiation was not significantly different among tall cultivars at both sites but the mean time taken for flower initiation at BE was nearly 6 years while at SE it was nearly 7 years. All the cultivars in general have taken greater period of time to initiate flowering at SE than at BE except the cultivar GDT. These findings can be explained by the comparative disadvantage of the marginal environment at SE site.

Table 1: ***Comparison of flowering at BE & SE (measured in months)***

	Mean (St. Dev)		**25% in flowering**		**75% in flowering**	
	BE	**SE**	**BE**	**SE**	**BE**	**SE**
GDT	55 a (12.1)	55 a (10.5)	48	47	60	60
YDT	58a (11.9)	64 b (13.8)	49	54	62	73
TT	71 b (15.37)	81 c (10.5)	62	73	78	88
MT	71 b (15.0)	85 c (12.3)	62	73	78	90
PPT	74 b (16.1)	84 c (10.9)	62	75	78	90

Nut Yield

Mean annual nut yield of all cultivars at both sites varied greatly over the years, but all cultivars followed a similar trend. Figures 1 and 2 show the annual variation of nut yield over the years at BE and SE respectively (note the missing data for 2001 and 2002 at SE site). Though the year to year yield variation could be generally explained by the variation of the rainfall, no concrete direct relationship between rainfall and yield variation could be established in some years in this experiment indicating that various other climatic and soil factors too are involved in influencing the final yield (i.e. yield during 2005) which warrants further investigations. Comprehensive analysis of nut yield data at both sites confirmed the superiority of both hybrids over the tall cultivars, GDT and YDT producing average of 13,838 and 12,895 nuts/ha/year respectively compared to 9764, 9509 and 8741 nuts/ha/year respectively for TT, PPT and MT at BE site and 11844, 10168 nuts/ha/year for GDT and YDT and 7141, 7319 and 8141 nuts/ha/year for TT, PPT and MT at SE site under average management conditions. Among the two hybrids the combining ability of Green Dwarf was better than Yellow Dwarf with Sri Lanka tall, GDT producing 7.3% and 16% more yield than YDT at BE and SE sites respectively. GDT showed the highest nut yield almost in every year at both sites and in several years the nut yield difference between GDT and YDT was statistically significant especially at SE (Figure 4).

An overall reduction in yield in all cultivars at the SE site was evident and that can again be explained by the comparative disadvantage of the class 4 and 5 soils which are marginal for coconut growing at the SE site compared to class 2 and 3 soils at BE. The data indicates that the highest achievable yield of GDT and YDT at the BE site were 20,506 and 18,296 nuts/ha/year while it was 18,768 and 15,967 at the SE site. The highest achievable yield of TT, MT, PPT at the BE site was 9764, 8741 and 9509 respectively while the same cultivars recorded 7141, 8141 and 7319 as the maximum yield at the SE site. The nut yield differences between hybrids and tall cultivars at BE and SE site are given in Figure 3. The mean yield increase of hybrids compared to that of tall cultivars was 44% and this is a great achievement of the coconut improvement programme. Hybrid was controversial from the very outset of its issue to growers because of the growers' misconception that the hybrid is drought sensitive and not suitable for rain-fed farming as limited information was available at the time of its release. This may be due to the fact that CRIC65 exhibit certain undesirable features such as snapping of bunches and as a result premature nut fall during the very early stage of its reproductive life. These results confirm that hybrids can be grown even under less favorable soils under rain fed condition. However, in situations where demand for coconut seedlings is very high and hybrid seed nuts are limited, it is important to grow hybrids in favorable environments and harness its full potential in order to address the countries national need.

The year 1996 and 2001 were drought years at the BE site and a high level of sensitivity to moisture stress was observed in all cultivars under evaluation at BE as reflected by about 37% average yield reduction compared to that of favourable years. The sensitivity of hybrids to moisture stress was observed to be marginally higher compared to tall cultivars as was evident by the percentage mean yield reduction, which was 40% in hybrids compared to 36% in tall cultivars. However as hybrids are producing 44% more yield than tall cultivars on an average, this marginal yield reduction during unfavorable situations does not seem to critically affect the overall performance of hybrids. These results indicate that hybrids can withstand moisture stress at least in the class 2 and 3 soils in the wet intermediate zone, but more data is needed from different soil types in order to make a firm conclusion on this fact.

Annual nut yield of three tall cultivars TT, MT and PPT at BE were not significantly different to each other however, the MT which was an estate selection from wet intermediate zone showed higher nut production compared to other two tall cultivars at SE and this difference was significant in 1998, 2003 and 2005. The nut number difference between MT and other tall cultivars are given in Figure 5. These results imply that MT which is a selection from wet intermediate zone has been able to harness its potential yields at SE which is located in wet zone compared to TT and PPT although the soil is marginal for coconut cultivation. Hence Moorock tall is identified as a suitable cultivar for marginal soils in Gampaha district (wet zone). TT and PPT did not show any significant difference in terms of nut yield over the years at both sites.

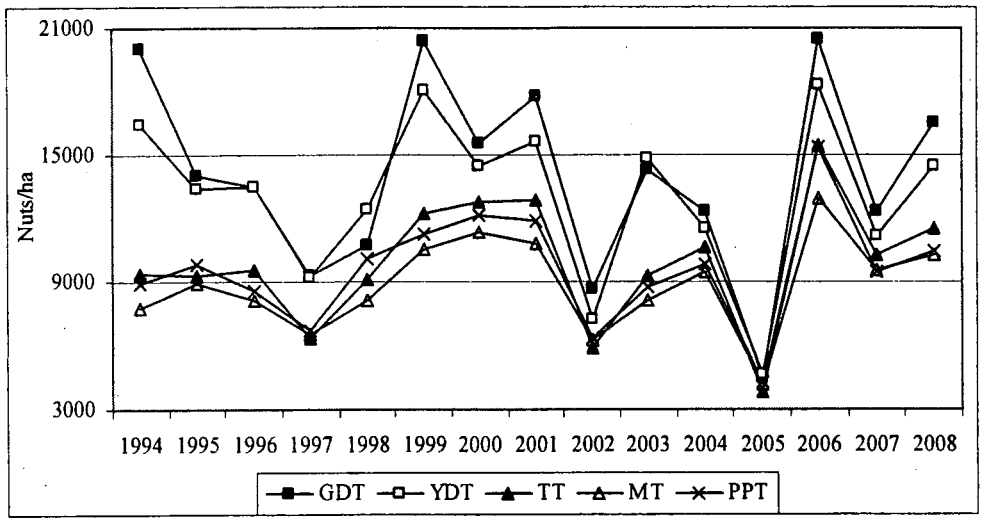


Figure 1: ***Mean annual nut yield variation at BE from 1994 to 2008***

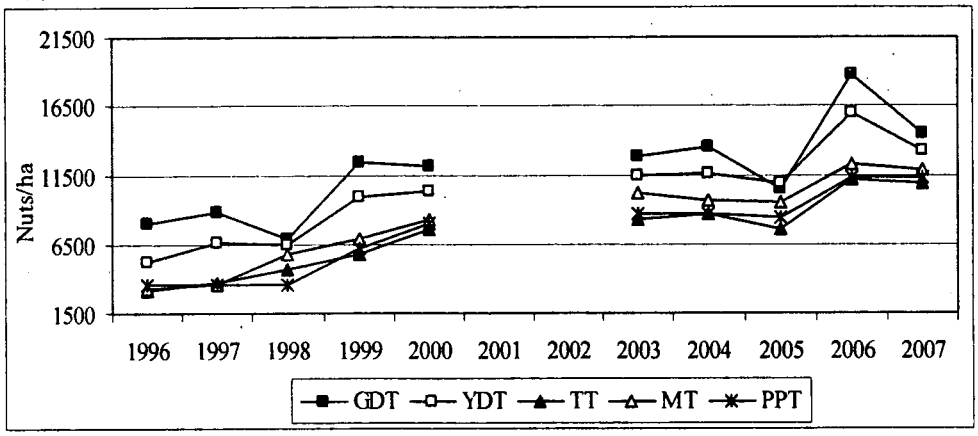


Figure 2: ***Mean annual nut yield variation at SE from 1996 to 2007***

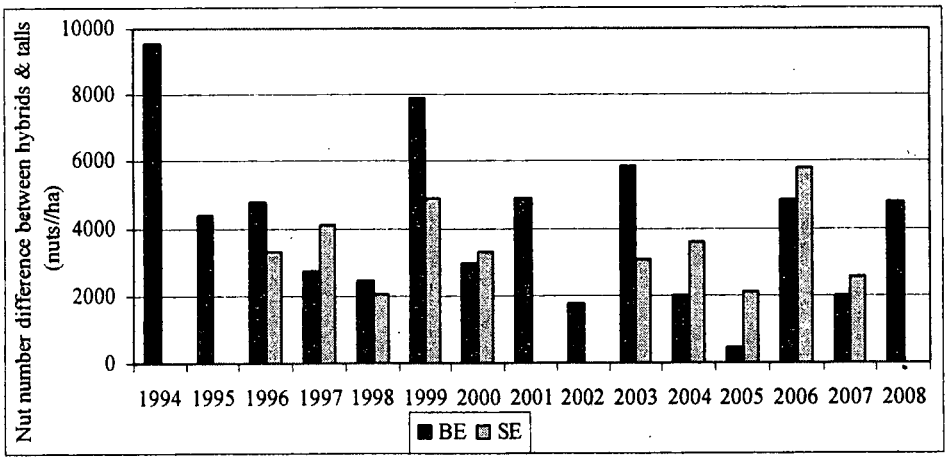


Figure 3: ***Nut yield difference between two hybrids and tall cultivars at BE & SE***

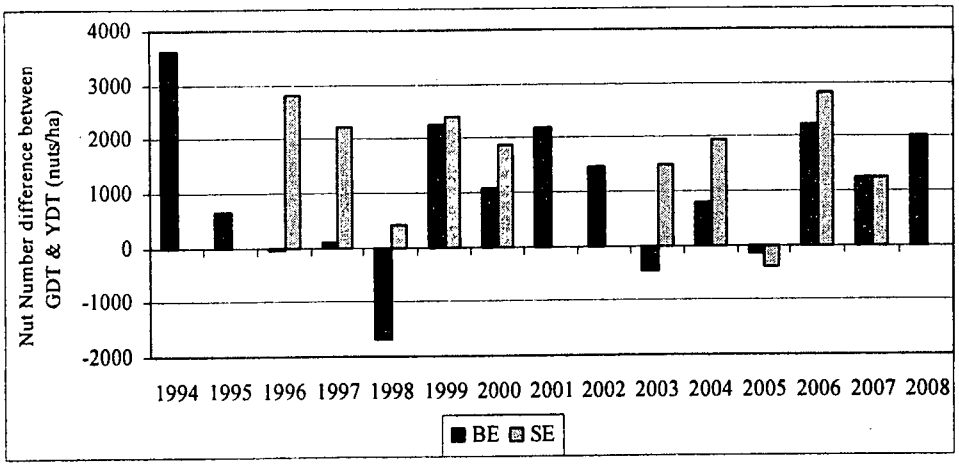


Figure 4: ***Nut yield difference between two forms of hybrids GDT and YDT***

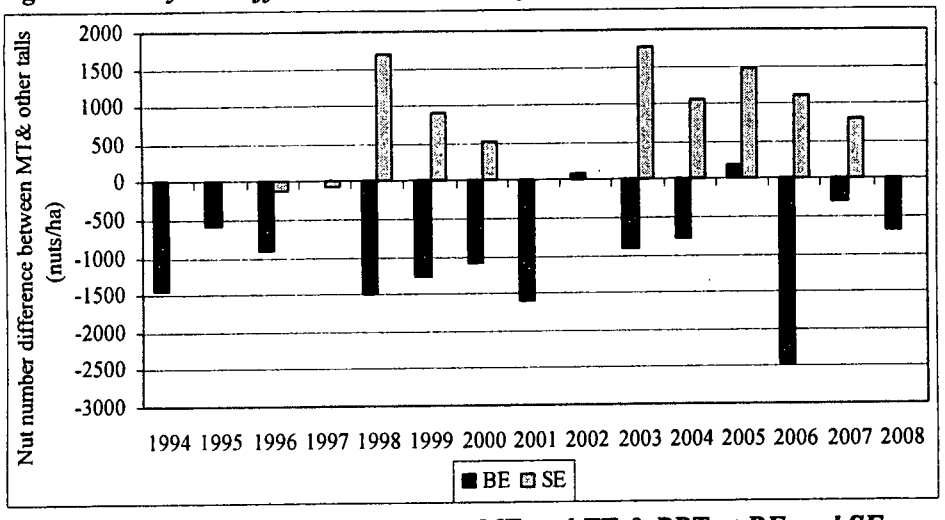


Figure 5: ***Nut yield difference between MT and TT & PPT at BE and SE***

The site at SE originally owned by a private owner and later sold out to Mr. W P Rupasinghe, a land seller in Gampaha district in 1998, who allowed the CRI to continuously collect the data from the experimental site, acquired his land back this year for his business, leaving the CRI only the BE site for further data collection. As enough information has already been gathered from this experiment it was decided to terminate the experiment from this year. However it was decided to collect only the individual nut yield data from this site in order to get more information related to yield versus age. As a result, yield recording was carried out in ten picks during the year and it was found that similar to previous years the two hybrids, GDT and YDT continued to outperform three tall cultivars (TT, PPT and MT) under average management conditions with total annual yield of 16,499 nuts/ha and 14,502 nuts/ha respectively this year. The annual nut yield difference between two hybrids was not significant while the difference of two hybrids GDT and YDT with other three tall cultivars were statistically significant. The average annual yields (nuts/ha/year) of TT, MT and PPT were 11,498, 10,274 and 10,415 respectively and there was no significant difference among these three cultivars.

Results of the fruit component analysis

Figure 6 summarizes the data obtained for fresh kernal weight production at two sites. At BE the highest kernal weights per nut were given by MT followed by TT. PPT recorded the

lowest kernal weights among the tall cultivars. At SE, the highest kernel weight was recorded in TT and it was significantly higher than that of PPT and MT. This indicates that TT has significantly responded to selection for kernal weight. Husked nut weight, which has a direct linear relationship with per nut kernal content, has been one of the main selection criteria for parents in TT. Husked nut weight has also recorded a higher heritability value 0.45 (Fernando, 1996) and this explains the superiority of TT in per nut kernal production compared to PPT. This finding along with the finding that TT respond to better environment at a higher rate than PPT (Annual Report 2007) in terms of nut number indicates the superiority of TT over PPT. This envisages the need of high input agriculture for TT cultivation in order to exploit its high genetic potential for yield. The estate selection Moorock tall has been specifically selected for its higher kernal thickness and that explains the higher kernal production of MT. Generally an inverse relationship was observed between the nut number and the per nut kernal content especially for MT at BE and TT at SE. This can be explained by the negative correlation of the nut number and the husked nut weight in coconut (Liyanage *et al*, 1988). The hybrids on the other hand produced comparatively lower kernal weight per nut (383 g/nut) than tall cultivars (408 g/nut). However this lower kernal content is more than compensated by the higher nut number produced by the hybrids. As a result hybrids remain the highest producers of kernal per unit land area (4.7 Mt/ha for DT and 3.5 Mt/ha for talls respectively (Figure 7).

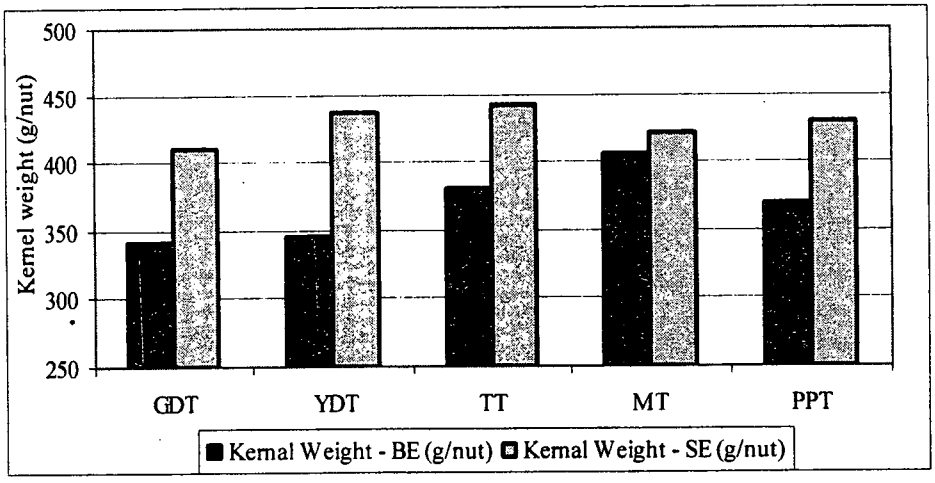


Figure 6: ***Per nut kernel weight of five cultivars at BE and SE***

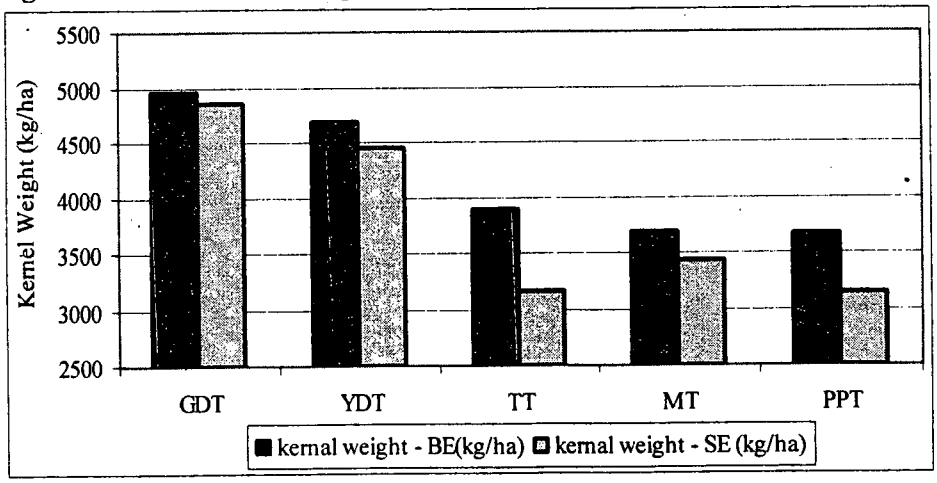


Figure 7: ***Total kernal production of five cultivars at BE and SE***

Other Fruit Component Analysis (FCA) data collected pick wise from 1994 to 2001 at the site BE and the data collected from 1998 to 2003 at the site SE were also analyzed during the year. In each pick twenty randomly selected fruits from each cultivar were collected and the weights of fresh fruit, husked nut, split nut, fresh kernel and the dry weight of 100g of kernel was measured. However, the dry weights were not recorded continuously. FC data were analyzed by general linear model procedure, repeated measure analysis and orthogonal contrasts to compare the differences among cultivars.

The data revealed that fruit components vary with the year, time of the year, site, and cultivar. It was also observed that the cultivar- time interaction is significant (Figure 8A, 8B, 8C and 8D). At BE site the three tall cultivars TT, MT and PPT were heavier than the two forms of hybrids irrespective of pick and the year. In an average the fresh weight of a fruit in three tall cultivars were 1535g while the average fresh weight of two hybrid forms was 1304g. The average kernel weight of tall cultivars was 389g while it was 346g in two forms of hybrids.

Among the three tall cultivars at BE, MT which is the lowest nut yielder gave the highest values for all the fruit components measured (Figure 9) at BE. MT was followed by TT and PPT and in several incidences TT produced significantly heavier nuts than PPT. The average fresh nut weight of MT, TT and PPT were 1615 g, 1501 g and 1470 g respectively while the kernel weight of MT, TT and PPT were 406 g, 380 g and 369g respectively. The least difference between TT and PPT were observed in weight of husks.

Between two hybrid forms at BE, YDT resulted heavier fruit components than GDT except for kernel weight. In several occasions YDT showed significantly higher weights than GDT for most of the fruit components measured. The highest difference between YDT and GDT was observed for husk weight indicating high proportion of husk in YDT on the weight basis. The average fresh nut weights of YDT and GDT were 1356g and 1252g respectively and the average kernel weights were 350g and 341g.

In general, out of five cultivars tested highest percentage of husks was observed in PPT (49%) and the lowest percentage of husks was observed in GDT while the highest percentage of kernel weight was observed in GDT (27%) and the lowest was observed in three tall cultivars (25%).

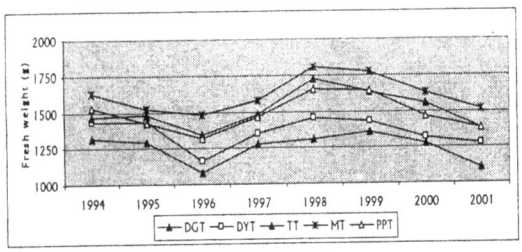


Figure 8.A *Variation of fresh weight of fruits at BE*

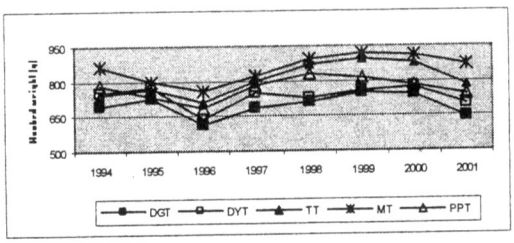


Figure 8.B *Variation of husked nut weight of fruits at BE*

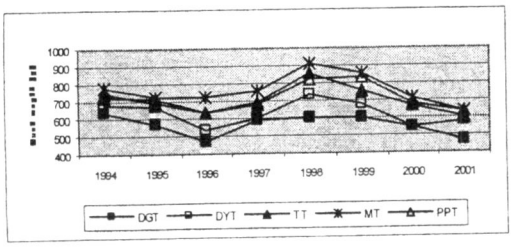


Figure 8.C *Variation of husk weight of fruits at BE*

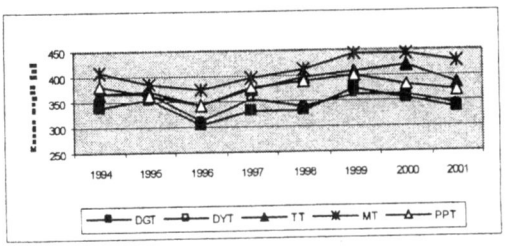


Figure 8.D *Variation of kernel weight of fruits at BE*

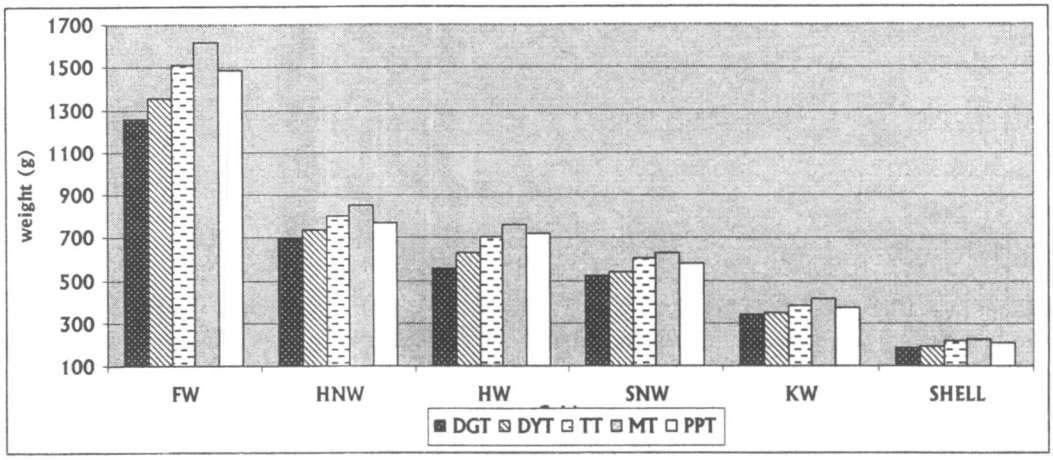


Figure 9. ***The average weights of fruit component of each cultivar at BE***

The same trends were not observed at the site SE (Figure 10) where no clear difference was observed between hybrids and talls. The cultivar YDT which is significantly lower nut yielder than GDT (discussed under the nut yield) produced heavier nuts than GDT and moreover the weights of fruit component of YDT were similar to tall cultivars. The highest weights were observed in TT which is the lowest nut yielder at SE. Similar to the findings at BE, TT produced significantly heavier nuts than PPT at SE too. The average fresh nut weight of TT, PPT and MT were 1619g, 1601g and 1566g respectively. The average kernel weights of TT, PPT and MT were 442g, 430g and 421g respectively. The husked nut weights were not significantly different among three tall cultivars.

The percentage of husks was similar in all three tall cultivars and it was 45% while the percentage of husks was 40% for hybrids. The highest percentage of kernel weight was observed in GDT (30%). The percentage of kernel weights of the three tall cultivars was 27% which is the lowest.

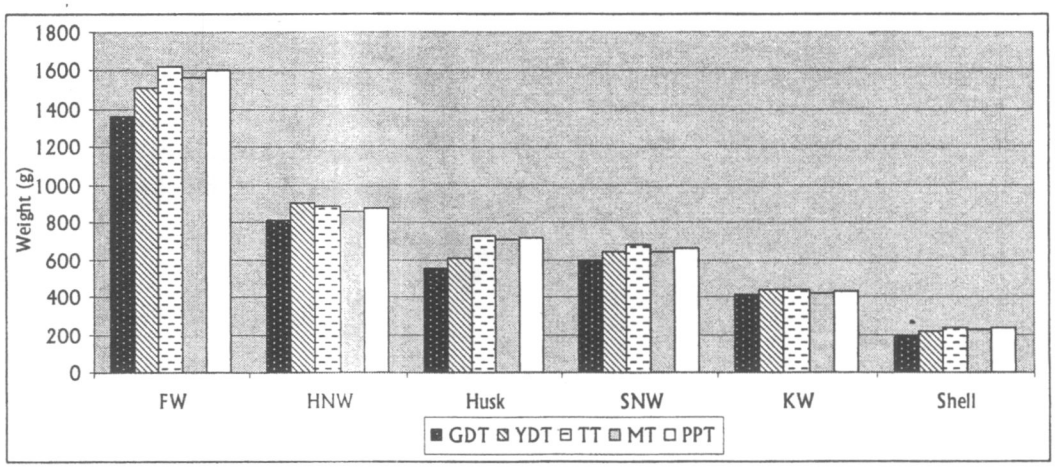


Figure 10. ***The average weights of fruit component of each cultivar at SE***

As can be generally expected, analysis of data at this site also revealed a negative correlation between nut number and the fruit component weights, higher nut yielders recording low fruit component weights and the vise versa for the poor nut yielders. Interestingly higher weights were observed at SE which is a less favorable site for all cultivars that recorded lower nut

yield in general compared to BE which is a comparatively a favorable site for coconut (Figure 11).

The data further seems to reveal that more of net assimilations of improved coconut cultivars; CRIC65 (two hybrid forms) and CRIC60 (TT) has been translocated to the kernel than the husk and shell compared to other cultivars.

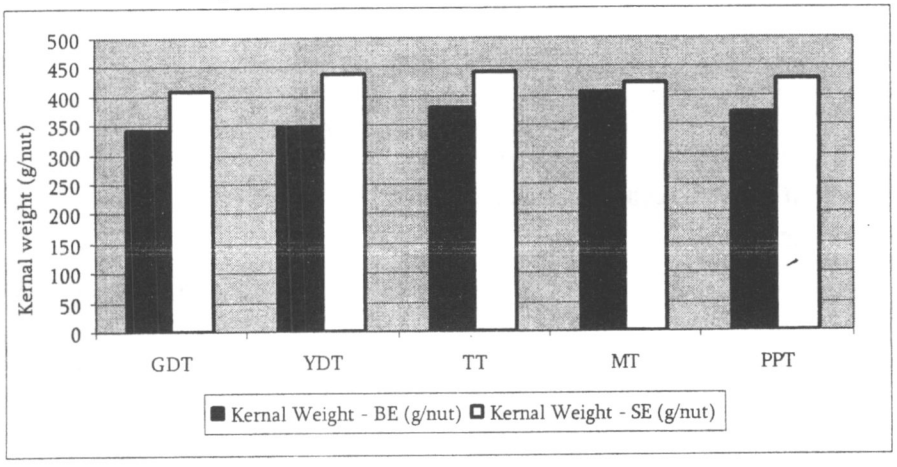


Figure 11. ***The kernel weights of each cultivar at BE and SE***

H D M A C Dissanayake, L Perera, W B S Fernando, R B Attanayake and H M N B Herath

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 at both ISG and PSG by hand pollinating 100 tall palms at ISG and 85 tall palms at PSG with SR pollen from palms at PRS. This programme produced a total of 11,665 seed nuts during the year 2008. The TSR pollination programme at ISG was terminated at the end of the year while another 103 new tall palms were included into the TSR pollination programme at PSG confining the total TSR pollination programme to PSG. A total of 1927 seedlings were issued to 15 adaptive trial sites this year and that included 8 sites in Puttalam district, 5 sites in Kurunegala district, 1 site in Kegalle and 1 site in Rathnapura district. Monitoring of these sites was in progress.

Production of Kapruwana was continued at ISG during the year by hand pollinating 50 dwarf green palms with SR pollen and a total of 3832 seed nuts were produced in 2008. The seeds were raised at ISG and issued to growers on the same conditions set out for issuing CRISL98. During the year, Kapruwana seedlings were issued to 7 growers; 2 Puttalum, 1 Gampaha , 1 Kurunegala, 1 Monaragala and 2 each in Kegole, districts.

During the year all selected TSR and Kapruwana sites was monitored.

M K Meegahakumbura, L Perera, S A S Chandrasiri and H M N B Herath

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)

These two trials were maintained successfully. Data collection not yet commenced.

L Perera and M H L Padmasiri

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

This trial was maintained satisfactorily.

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. Since palms had not attained yield stability yet, Fruit Component analysis was not done as expected.

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

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)

Nut yield was recorded at BE, RE and Andigama-Mudalihamy sites while nut yield recording and fruit component studies were carried out in 2008 in all the other sites except Mangala Eliya which is an abandoned site.

Table 2: ***Annual nut yield of different crosses at different sites***

Site	TxSR	TxGD	TxT	GDxSR	DGxT	YDxT
BE	71.5 b	89.0 a	89.0 a	-	-	-
RE	60.3 c	88.7 a	72.3 b	-	-	-
DV	88.6 c	122.2 a	98.1 bc	101.0 b	121.6 a	-
Puras	76.6 b	88.1 a	76.7 b	89.3 a	-	-
Mudalihamy	91.4 a	85.5 a	99.0 a	-	-	-
Sirikandura	66.5 a	52.3 b	66.4 a	-	-	60.0 ab

Nut yielding pattern of different crosses varied among sites and statistically significant differences were observed for annual nut yield in different crosses in all sites except at Andigama-Mudalihamy site. Nut yield in decreasing order was T x GD, GD x T, GD x SR, T x T and T x SR at BE, RE and DV. However, the superiority of T x GD as a nut producer is not to be seen at marginal sites for coconut cultivation at Andigama-Puras and Sirikandura sites.

Table 3: ***Results of the fruit component study***

	Puras	**Sirikandura**	**DV**	**BE**
TSR -	2016.8 a	2091.9 a	2395.5 a	--
FNW	858.3 a	895.5 a	1031.8 a	
	631.5 a	657.1 a	754.4 a	
HNW	378.5 a	396.0 a	467.6 a	
SNW				
KW				
TGD -	1408.9 c	1581.9 c	--	1407.0 b
FNW	583.5 c	664.5 b		780.9 b
	449.7 c	494.9 b		576.5 b
HNW	272.8 c	304.3 b		369.9 b
SNW				
KW				
TT -	1661.1 b	1987.1 b	--	--
FNW	699.8 b	901.1 a		
	539.4 b	657.7 a		
HNW	314.6 b	407.9 a		
SNW				
KW				
GDSR -	1587.8 c	--	1914.2 b	1799.9 a

FNW	715.1 b		943.0 b	983.9 a
	522.7 b		669.2 b	690.0 a
HNW	318.4 b		427.4 b	452.6 a
SNW				
KW				
SRGD - FNW	--	--	--	1724.9 a
				988.4 a
HNW				707.3 a
				450.9 a
SNW				
KW				
TYD - FNW	--	1527.3 d	--	
		634.6 b		
HNW		475.6 b		
SNW		286.6 c		
KW				

Note: Mean comparison has been done among cultivars within a site for each component. Means with the same letter are not significantly different.

As in the previous years T x SR performed superior to other crosses in all the sites evaluated. However, as shown in the table 3 the cross T x T performed equally well at Sirikandura with respect to HNW, SNW and KW. GD x SR was the second best cross with respect to fruit components analyzed while the performance of T x T was equally good at Andigama-Puras where both GD x SR and T x T were evaluated in comparison. However, this was not true at BE where GD x SR outperformed T x GD with respect to all the components of the fruit. As expected T x GD, GD x T and T x YD recorded the lowest weights for the fruit components analyzed. The comparative evaluation of GD x SR and its reciprocal cross SR x GD did not show any significant differences between the two crosses.

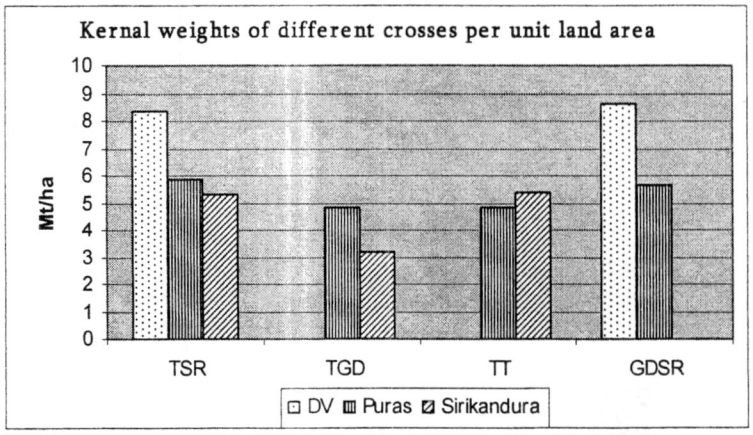


Figure 8: ***Kernal weights of different crosses per unit area.***

S A C N Perera, L Perera, H M N B Herath, R B Attanayake, S A S Chandrasiri, and G K Ekanayake

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

Locations and agro-climatic conditions

Exp. N0.	Location	Year established	Soil type	Agro-ecological zone
4.1	Raddegoda	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 the sites at Raddegoda and Ratmalagara were maintained satisfactorily. However at the end of 2008 the site at Wanathawilluwa was severely affected by water logged condition. The site at Bandirippuwa, which was planted with over-grown seedlings, suffered drought damage leaving several vacancies. Therefore this site will be continued as an observation trial.

In Raddegoda estate, Ratmalagara estate and Wanathawilluwa estate the number of leaves produced during 6 months period and the months taken for first flowering were recorded. In BE site number of leaves produced during 6 months period and the height measurements were taken. The circumference at girth was not recorded because of the wire mesh coverings around the girth area of the seedlings.

According to the data obtained, the rate of leaf production showed significant differences among cultivars and most of the hybrid crosses showed a higher rate of leaf production than tall cultivars. However, a general pattern could not be identified using the data obtained.

Month of first flowering was recorded in first three sites and as expected hybrids show early flowering than the two tall varieties CRIC60 and CRISL98. The following table shows the percentage of palms in flowering of each cultivar at each site at the end of the year.

Table 4: *% flowering of each variety at Raddegoda, Ratmalagara and Wanatawilluwa sites.*

Variety	*Raddegoda*	*Ratmalagara*	*Wanatawilluwa*
BDSR	72 %	29 %	-
BDT	76 %	25 %	23 %
Kapruwana	89 %	18 %	58 %
CRIC65	78 %	25 %	52 %
TBD	78 %	14 %	13 %
CRISL98	21 %	nil	3 %
CRIC60	nil	nil	nil

PRODUCTION OF T X BD AND SR X BD FOR FARMER FIELD ADAPTIVE TRIALS

A pollination programme was commenced to produce T x BD and SR x BD seedlings to plant in farmer fields as adaptive trials. Twenty seven San Ramon palms from field no.2 and sixteen CRIC60 palms from Field no. 6 were selected from Pallama Seed Garden and the following number of inflorescence were pollinated with Brown Dwarf pollen. The first seed lot will be harvested in January 2009.

Table 5*: Progress of the pollination programme of T x DB and SR x DB sites.*

Month	*No. of San ramon inflorescence*	*No. of San ramon buttons*	*No. of CRIC60 inflorescence*	*No. of CRIC60 buttons*
Jan	25	453	19	374
Feb	28	450	18	377
Mar	40	627	22	452
Apr	35	589	23	509
May	46	756	25	509
Jun	41	672	24	521
Jul	43	707	24	501
Aug	41	691	24	528
Sep	44	749	25	540
Oct	37	655	20	454
Nov	38	725	20	421
Dec	5	101	4	89
Total	*423*	*7175*	*248*	*5275*

FRUIT COMPONENT ANALYSIS OF THE NATURAL HYBRIDS OF BROWN DWARF

During the year fruit component data of the natural hybrids of brown dwarf at Poththukkulama Research Station were recorded in six picks. For the comparison purpose fruit component data of thirty nuts collected from 30 CRIC60 palms in the same field were recorded in each pick.

The data analysis revealed that in contrast to other hybrid forms all the fruit components (Fresh weight, husked nut weight, split nut weight, kernel weight, weight of coconut water, and shell weight) were significantly greater in natural hybrids of brown dwarf than CRIC60 except the weight of husk which was not significantly different between the two forms. The following figure shows the variation in fruit components between the two forms.

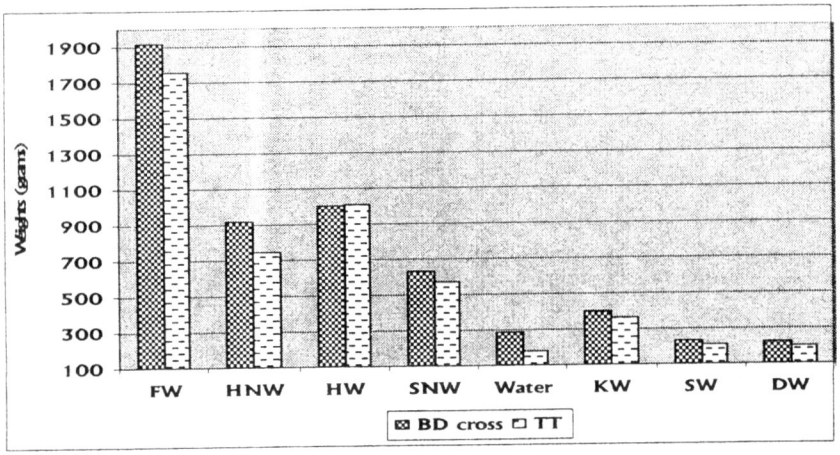


Figure 9: ***Variation in fruit components between DB x T and TT.***

H D M A C Dissanayake, L Perera, , H M N B Herath, R B Attananayke, M H L Padmasiri, S A S Chandrasiri

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

During the year only the crossing programme of San Ramon (SR) x Malayan Red Dwarf (MRD) continued until June as sufficient seed nuts were harvested from other crosses. The summary of seed nuts harvested and laid during the year is given in table 6.

Table 6: ***Summary of the pollination programme at the Pallama Seed Garden and Isolated seed garden at Ambakelle.***

Location	Cross	Setting up to September 2008	Seed nuts harvested laid at the BE nursery
Pallama Seed Garden	T x RIT	-	1535
	T x TAGT	-	2008
	T x MRD	-	1727
	SR x MRD	1365	618
Isolated Seed Garden	DG x RIT	-	749
	DG x TAGT	-	706

(RIT: Rennel Island Tall, TAGT: Tagnanan Tall, MRD: Malayan Red Dwarf)

During the year four multi-locational trials were planted at Marandawila Farm (NLDB) in Bingiriya, Beligama Farm (NLDB) in Melsiripura, Siringapatha Farm (NLDB) in Badalgama and Middeniya Sub Research Station in Down South. In addition to the statistically designed four multi-locational trails, two observational trials were also planted at Pottukulama Research Station and at Wanathawilluwa (private estate). During the year NLDB farm at Kaduruwela in Polommaruwa district was also identified as a prospective site for establishment of another multi-locational trial with these crosses. The summary of the planting details are given in table 7.

Table 7: ***Summary of the planting details of exotic crosses.***

Location	Soil type	Agro-Ecological zone	Crosses	Total seedlings
Marandawila	(Loamy sand, sandy loam to sandy clay loam)	Dry intermediate zone	TxRIT, TxTAGT, TxMRD TxBGD, DGxRIT, DGxTAGT, DGxSR, TxSR, DxT	460
Beligama	(Sandy clay loam to clay loam)	Dry intermediate zone	TxRIT, TxTAGT, TxMRD TxBGD, DGxSR, TxSR, DxT	422
Middeniya	(Sandy clay loam to clay loam)	Dry zone	TxRIT, TxTAGT, TxMRD TxBGD, DGxSR, TxSR, DxT	401
Siringapatha	(Loamy sand, sandy loam)	Wet Zone	TxRIT, TxTAGT, TxMRD TxBGD, DGxRIT, DGxTAGT, SRxMRD, DGxSR, TxSR, DxT	430
Observational Plots				
Pottukulama	(Sandy loam)	Dry intermediate zone	TxRIT, TxTAGT, TxMRD TxBGD, DGxRIT, DGxTAGT SRxMRD, TxBD, SRxBD, DxT	322
Wanatawilluwa	(Sandy loam)	Dry zone	TxMRD, DGxSR, TxSR, TxT	306

M K Meegahakumbura, L Perera, S A C N Perera, M H L Padmasiri H M N B Herath, R B Attanayake, G K Ekanayake and S A S Chandrasiri

PROJECT: SCREENING OF COCONUT VARIETIES/CULTIVARS FOR MITE TOLERANCE AND DEVELOPMENT OF COCONUT HYBRIDS/CULTIVARS TOLERANT TO *ACERIA* MITE (2005)

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

The crossing programme using local [Sri Lanka Tall (SLT), Gon Thembili (GT) and Yellow Dwarf (YD)] and a few exotic varieties with round shape nuts [Brazilian Green Dwarf (BGD), San Ramon (SR)] was continued in 2008. The round shape nuts were observed to be less susceptible for mite attack and the probable reason for that was identified as the tight attachment of the perianth to the nut which prevents the *Aceria* mite moving underneath the perianth. The objectives of the crossing programme were to identify *Aceria* mite tolerant hybrids and exploit 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. Two thousand six hundred and sixty eight

SLT x BGD, 122 BGD x GT, 380 GT x BGD, 127 SR x BGD and 314 YD x GT cross pollinated seed nuts have been nursery laid in the year 2008. Seedlings of the cross T x BGD were field planted along with exotic crosses in multilocational trials at Beligama Farm, Marandawila Farm, Middeniya Research Station and Siringapatha Farm. T x BDG was also planted in an observational trial at Pottukulama Research Station. The pollination programme is continued and it is expected to plant a field evaluation trial with these crosses in 2009.

S A C N Perera, L Perera, M H L Padmasiri, S A S Chandrasiri and A A Fernando

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

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. Based on this observation studies were initiated in 2006 to assess the potential of GT to be recommended as a pure cultivar for highly mite infested areas. The nut counting study in 2006-2007 did not reveal significant differences between TT and GT. Fruit component study was continued in the year 2008 (table 8) .

Fruit component data [Fresh nut weight (FNW), Husked nut weight (HNW), Split nut weight (SNW), Kernel weight (KW)] and dry weight of 100 g of fresh kernel (DW) recorded at 6 times in a sample of 40 nuts are given in table 8.

Table 8: ***Fruit component data of GT and TT***

	FNW	HNW	SNW	KW	DW/100g
GT	1828.8 a	768.7 a	579.9 a	352.4 a	52.7 a
TxT	1616.8 b	723.9 b	550.2 b	336.5 b	52.3 a

The detailed fruit component analysis spanning through 6 picks in the year 2008 revealed the superiority of GT in terms of all the components of the fruit while this difference was statistically different for all components except the dry weight of 100 grams of the kernel. The study further display the comparative performance of GT as a pure cultivar compared to TT. The research is in progress and it is expected to study the transmission of GT characters into the subsequent generations.

S A C N Perera and G K Ekanayake

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

The 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. Studies have been in progress in 2008 to develop a segregating population for mapping QTL governing mite tolerance.

The hand pollination programme for crossing *Aceria* mite tolerant yellow dwarf palms with pollen from a highly susceptible Sri Lanka Tall palm resulted in a total of 995 seedlings which have been nursery laid in the year 2008. The pollination programme is now concluded and it is expected to field plant the seedlings in the year 2009.

S A C N Perera, L Perera, A A Fernando and GK Ekanayake

PROJECT: DEVELOPMENT OF DWARF X DWARF COCONUT HYBRIDS

During the year pollination programme was continued only for Brown Dwarf x Green Dwarf, Red Dwarf x Brown Dwarf and Cameroon Red Dwarf (CRD) x Green Dwarf as the Yellow Dwarf palms identified for the pollination at PRS showed some degree of cross pollination. This coincides with the observation that the Sri Lanka Yellow Dwarf show greater morphological variability among palms.

The details of the pollination programme are given below.

Cross	Setting up to September 2008
BD x GD	218
RD x BD	435
CRD x GD	380

L Perera, M K Meegahakumbura and M H L Padmasiri

PROJECT: COCONUT GENOME MAPPING

During the year growth measurements were recorded twice in six monthly intervals in the field. The plantation with mapping population was maintained satisfactorily.

DNA extracted from parents and the progeny of the mapping population was sent to ICRISAT/India for genotyping under the grant received from the Generation Challenge Programme of the Consultative Group of International Agricultural Research (CGIAR). The genotyping of the parents in order to determine the informative primers for the genotyping of the progeny was completed during the year and results were obtained.

Out of 244 primer pairs initially tested at ICRISAT between parent 1 (Sri Lanka tall) and parent 2 (Sri Lanka Red Dwarf), only 185 have yielded PCR amplification in both parents. Due to some unknown reasons, other primers have not amplified in either of the parents. Out of the 185 active SSRs, only 6 SSR were fully informative in both parents (both parents are heterozygous with one or both alleles different between them) while 48 SSRs were fully informative in parent 1 and 5 SSRs were fully informative in parent 2 (one of the parents was heterozygous and one or both alleles of the heterozygous parent different to the homozygous parent). Four (4) SSRs were also only partially informative, both parents having exactly the same heterozygous alleles at each respective 4 SSR loci (i.e Parent 1 and parent 2 both possessed alleles 220 bp & 256bp). Therefore although alleles of the partially informative 4 SSR loci are segregating in both parents, it is not possible to determine the parental origin of the alleles for the heterozygous offspring in the mapping population. As a consequence, there

are only 58 SSR markers (30% of the markers) remaining to be used in genotyping the mapping population. These markers provide useful information to build the map, but since they are not many, this map may not be a practically useful map for marker assisted selection in coconut. Thus it is necessary to assess whether another marker system preferably the DArTs, would provide necessary polymorphism between progenitors and the progeny, before continuing the project.

S A C N Perera, L Perera, W B S Fernando, G K Ekanayake

PROJECT: COLLECTION CONSERVATION AND EVALUATION OF COCONUT GERMPLASM

ENRICHMENT OF COCONUT GERMPLASM

Importation of Coconut Germplasm

The exotic gene-bank established at BE was maintained satisfactorily this year. Attempts made to import another batch of coconut embryos from Papua New Guinea failed due to no approval granted for the mission by the Ministry of Plantation Industries.

L Perera, M.K.Meegahakumbura, and R B Attanayake

EVALUATION OF CONSERVED COCONUT GERMPLASM

Collection and conservation of coconut biodiversity within the country

The germplasm conservation blocks (field 7 and 10) at Margaret estate were maintained well although there was a damage to the field 10 by an elephant at the latter part of the year resulting death of seventeen palms. During the year the field 10 was expanded with the seedlings collected under the Unawatuna diversity project and with indigenous coconut germplasm. Three hundred and seventeen new seed holes were prepared for planting and the planting was done at the end of the year. The tables 9A & 9B show the current status of the gene banks at Margaret estate.

Table 9A: ***Current status of the Margaret Estate (Field 07) gene-bank***

Accession	*Young palms*	*Bearing palms*	*Vacancies*	*Total*
Thelandiriya	11	32	10	53
Kalawewa	14	43	03	60
Sidurupitiya	19	4	5	28
Ambakelle special	20	38	2	60
Galenbidunuwewa	19	26	15	60
Vijithapura	06	46	09	61
Hangiligama	11	48	1	60
Mahawalatenna	22	21	11	54
Lanlib	23	33	4	60
Wanathawilluwa	40	14	6	60
Ihalakagama	35	22	3	60
Blackstone	35	12	10	57
Total	255	339	79	673

Table 9B: ***Current status of the Margaret Estate (Field 10) gene-bank***

Accession	*Survivals*	*Vacancies*	*Total*
Batheegama	41	19	60
Diddenipotha	49	11	60
Aparekka	32	28	60
Kirulapone	42	8	50
Gannoruwa	36	11	47
Kalagedihena	46	14	60
Yakkala	44	16	60
Bogamuwa	20	40	60
Nittambuwa	54	6	60
Rambukkana	45	15	60
Ampara	45	27	72
Damana	7	43	50
Deegawapi	29	18	47
Ranthembili	47	38	85
Gonthembili	15	14	29
Bodiri	21	47	68
Kamandala	1	3	4
Porapol	1	7	8
Cameroon red dwarf	30	0	30
Red dwarf	35	6	41
Murusi	26	0	26
Spikata	1	10	11
Muthiyangana	29	59	88
Baticaloa	0	3	3
Jaffna	1	2	3
Thirukkovil	5	3	8
Brown dwarf*	34	0	34
Ocean hill*	15	0	15
Dothalu*	20	0	20
Malaysian coconut*	20	0	20
Red gon thembili*	19	0	19
Brown murusi*	6	0	6
Yellow murusi*	7	0	7
Ranpol*	14	0	14
Jambola pol*	3	0	3
Juwan (deviant) – ZM*	13	0	13
Ocean hill2 (UG)*	1	0	1
Tewatta (TG)*	1	0	1
Juwan*	38	0	38
Gon thembili (Unawatuna)*	2	0	2
Thatin*	19	0	19
Nawasi*	31	0	31
Bothal thembili*	12	0	12
Nawasi thembili*	14	0	14
Rath ran thembili*	3	0	3
Plus palm (Unawatuna)*	21	0	21
Total	995	448	1443

(* Planted in December, 2008 and January, 2009)

A single typica tall palm bearing very big nuts was identified at Margaret Estate, Pallama and it was self-pollinated to purify and multiply the distinguish phenotype. Resulting nuts were harvested this year and was nursery laid.

Collection of coconuts from the cold areas in the country aiming at cold tolerance coconut germplasm did not happen this year due to financial and human resource constraints. All gene-banks were maintained satisfactorily this year too.

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

Collection, conservation and evaluation of coconut biodiversity in the Southern Province
Molecular data collection to reveal the genetic diversity of the newly collected phenotypes in comparison to the existing varieties and forms was undertaken in 2008. Accordingly 40 individuals belonging to the above phenotypes were genotyped with 14 SSR markers. Both morphological and molecular data will be extensively analyzed within the year. The resultant dendrogram of the molecular data is given (Figure 10).
A total of 146 open pollinated seednuts belonging to the phenotypes Brown Murusi, Ran Pol, Bothal Thembili and Yellow Murusi were nursery laid during the year.

G K Ekanayake (Full time M.Phil study), S A C N Perera and J M D T Everard [Deputy Director (Research) P N Dassanayake (University of Sri Jayawaedenepura]

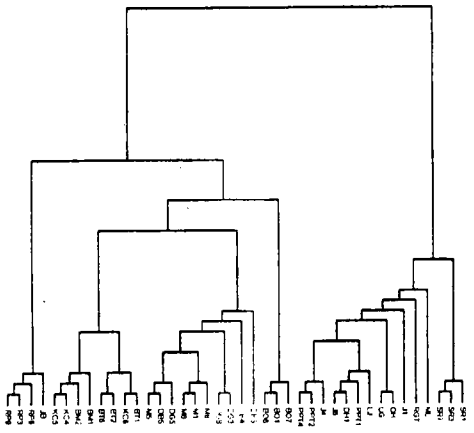


Figure 10: ***Dendrogram showing the genetic relationships between Unawatuna variety collection using 13 SSR primers.***

CHARACTERIZATION OF COCONUT GERMPLASM

Characterization and evaluation of indigenous Thembili germplasm (1996)

The trials at Margaret Estate and Raddegoda Estate were maintained.

S A C N Perera and R B Attanayake

PROJECT: MOLECULAR PATHOGEN DIAGNOSIS

Financial constrains and human resource scarcity hampered the project work for a certain extent during the year. Leaf tissues and disease stages; mild and moderate were identified as the best tissue type and the best disease severity stages for the easy detection of phytoplasma during the dry season. The involvement of the phytoplasma in casuing the Weligama Coconut Leaf Wilt disease (WCWLD) was reconfirmed during the year by cloning and sequencing the PCR amplicon at the University of Nottingham. Designing of WCWLD specific PCR primers and identification and confirmation of vectors of the disease will be done next year.

L Perera, M K Meegahakumbura, W B S Fernando

DEVELOPMENT PROJECTS

(A) Increase of CRIC65 seed nut production at the ISG

During the year field 9 was under planted with yellow dwarf seedlings. The adjoining jungle within the field 9 was also cleared and planted with yellow dwarfs to make the total number of yellow dwarf seedlings planted this year at ISG to 1000 seedlings.

The routine emasculation programme at ISG continued smoothly and a significant yield increase was observed due to the banning of removal of female flowers imposed in 2006.

Steps were taken to extend the nursery area of the ISG in order to produce more seedlings at ISG for the growers.

L Perera and A A Fernando

(D) Establishment of Pallama Seed Garden (PSG)

During the year 434 San Ramon seedlings as guard rows and 1600 tall seedlings as seed palms within the seed garden were planted. The pollination programme to self pollinate San Ramon at PRS continued this year too and 1104 selfed San Ramon resulted from the pollination programme were nursery laid both at BE and PSG. 2296 tall x tall seed nuts resulting from the hand pollination programme carried out during 2007 at Field 4 at PSG which was terminated last year were also laid at the PSG nursery.

Production of CRISL98 by hand pollination of tall palms with San Ramon pollen at the seed garden was continued. The palms in pollination were increased up to 185 this year. Total of 2508 TSR seed nuts harvested were laid at PSG nursery. The first batch of TSR seedlings (CRISL98) from the PSG will be ready to issue from the beginning of the next year for the first time

M K Meegahakumbura, L Perera and M H L Padmasiri

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

Two hundred planting holes were prepared for infilling the half sib family seedlings at the field number 07 of MOSG, but planting was postponed to early 2009 as the field was waterlogged after rains.

L Perera and M K Meegahakumbura

(E) Establishment of a seed garden for Kapruwana

Acquiring of Kiniyama estate for establishment of the seed garden for "Kapruwana" coconut hybrid did not happen this year too. About 2000 green dwarf seed nuts were collected from various places and nursery laid for the purpose of planting at Kiniyama.

L Perera, S A C N C Perera, H D M A C Dissanayake, M K Meegahakumbura and R B Attanayake

(F) Establishment of Seed Certification Unit

During the year, seven new coconut estates were designated as Plus Palm estates for the supply of seed nuts for the National Replanting Programme and total of 8,173 new palms comprising 1,732 from Carsfield estate, 549 from Rajasanthaka estate, 792 from Kolawaturayaya estate, 961 from Ranawana estate, 732 from Dispensary estate, 492 from Nagansole estate and 2915 from Horakelley estate were selected.

During the year 784,465 CRIC60 seed nuts from ISG and 409591 CRIC60 from MOSG and 91885 CRIC65 seed nuts from ISG were supplied to CCB, registered private nurseries and CRI estate nurseries during the year under the supervision of Seed and Seedling Certification Officer of the Seed Certification Unit. Seedling certification which was restricted to CRIC60 and CRIC65 polybagged coconut seedlings last year extended to Moorock tall also this year and accordingly and total of 384838 coconut seedlings were certified this year.

During the year new registration was given to 6 private coconut nurseries making the total private nurseries in operating in Sri Lanka 14.

R Jayathilake and L Perera

Staff Matters

Extension activities

The staff of the Genetics & Plant Breeding Division involved in organizing and conducting the first programme of the One day training programme series of year 2007 of the CRI on "Replanting of coconut" at the Isolated Seed garden, Ambakelle, May 2007

Dr. L Perera, Dr. (Miss) S A C N Perera and Mr. L M S R Jayathilake, Mr. S A D W Priyankara, Mr. R C M Wijerathne, Mr. R I B C T Herath, conducted and training programme for newly recruited nursery officers and Coconut Development Officers of the Coconut Cultivation Board on 03, 05, 07 March 2008.

Mr. R Jayathilake delivered lectures on Nursery management and Seedling Certification to Coconut Nursery Officers of the CCB on 17 July 2008

The staff of the Genetics & Plant Breeding Division delivered lectures to 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 Genetics & Plant Breeding Division, molecular biology laboratory and the Isolated Seed Garden at Ambakelle.

Research Grants

Dr. L perera, Dr. S A C N Perera, M G M K Meegahakumbura and H D M A C Dissanayaka received a research grant worth of USD 30,000 from the crop Diversity Trust of the IPGRI for the project titled "Characterization of Indigenous coconut germplasm in Sri Lanka"

Awards

Dissanayaka H D M A C, Perera S A C N, Fernando W B S, Attanayake R B, Meegahakumbura M G M K and Perera L received the Best paper and best presentation award in the coconut sector at the second Plantation Crop Research Symposium, BMICH, Colombo (2008) for the paper titled "Evaluation of the comparative performance of five commercial coconut cultivars under two different agro-ecological zones in Sri Lanka"

Wijesekara, H T R, Perera L, Wickramananda, I R, Hearth, I, Meegahakumbura M K, Fernando, W B S and de Silva P H P R received the best Poster award in the coconut sector at the second Plantation Crop Research Symposium, BMICH, Colombo (2008) for the poster titled "Weligama Coconut Leaf Wilt Disease: A new disease in Southern Sri Lanka"

REPORT OF THE SOILS AND PLANT NUTRITION DIVISION

Head – N A Tennakoon, PhD

1. SUMMARY

The Research programme of the Division was aimed at refining technology on nutrient management particularly with inorganic fertilizer and locally available organic sources, maintain soil quality by application of organic manures, evaluating nutrient levels of different types of coconut growing soils, assessment of soil fertility in coconut lands and developing irrigation/fertigation techniques for coconut.

During the year, the Division maintained 20 on-going field experiments and 2 green house experiments under 8 projects. Three new field experiments were also commenced during the year. A few miscellaneous studies were also conducted to support the ongoing major experiments. The total research expenditure as consolidated funds for research was Rs. 10,305,000/-. A sum of Rs. 256,630/- were also received from the Ministry of Agriculture Development under the organic manure project.

According to the results of the experiment on different sources of phosphate namely Triple Super Phosphate, Imported Rock Phosphate and Eppawela Rock Phosphate there was no significant difference in nut yield even 17 years after the establishment of the experiment at Ratmalagara Estate (IL_1a). Leaf phosphorus content was also not shown significant differences among the Eppawala Rock Phosphate and Imported Rock Phosphate applied coconut palms. Therefore the recommendation of Eppawela Rock Phosphate as a P source specially for Wet and Intermediate zones can be continued and this will lead to a substantial savings of foreign exchange. The Cd accumulation in soil, leaf, kernel and nut water after long-term application (17 years) of these 3 sources of P fertilizer have not exceeded the contaminated level (i.e. soil < 0.5 mg/kg, plant material < 0.2 mg/kg). However there is a tendency of Cd accumulation in the kernel of IRP-treated coconut palms than that of ERP-treated palms.

The experiment on site specific fertilizer recommendation at Sirigampola (IL_1a, Madampe soil series - S_2), showed a significant increase (87%) in nut yield ($p \leq 0.001$) from the palms receiving 1700 g Urea, 1905 g Eppawala Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over the control (no fertilizer) and 34% nut yield increase in the recommended fertilizer (T_2 - 800 g Urea, 900 g Eppawala Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite) treated palms over the control. Increase of Urea by 900 g, Eppawala Rock Phosphate by 1005 g, Muriate of Potash by 1800 g and Dolomite by 1125 g (T_5) have shown the highest nut yield (39%) compared to the recommended dosage (T_2). The same experiment at Wellawa (IL_1a Kurunegala soil series - S_2), showed 60% significant increase in nut yield ($p \leq 0.001$) from the palms receiving 1400 g Urea, 1050 g Eppawela Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (Treatment 4) over control (no fertilizer) and 49% increase in nut yield were observed in the recommended fertilizer treated palms (T_2 800 g Urea, 900 g Eppawala Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite) over the control. Increase of Urea by 600 g, Eppawela Rock Phosphate by 670 g, Muriate of Potash by 1200 g and Dolomite by 750 g (T_4) have shown the highest nut yield (7%) compared to the recommended dosage (T_2). The same experiment at Kobeigane (IL_1b Wariyapola soil series - S_3) 51% nut yield increase was observed significantly ($p \leq 0.01$) 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 13% nut yield increase was observed in the recommended fertilizer treated palms (T_2 - 800 g Urea, 900 g Eppawala Rock Phosphate, 1600 g Muriate of Potash and 1000g Dolomite) over the control. Increase of Urea by 600 g, Eppawala Rock Phosphate by 670 g, Muriate of Potash by 1200 g and Dolomite by 750 g (T_4) have shown the highest nut yield (34%) compared to the recommended dosage (T_2). The site at Mangalaeliya (DL_3, Borupan soil series - S_2) showed significant increase in 117% nut yield ($p \leq 0.001$) from the palms receiving 1700 g Urea, 1225 g, Imported Rock Phosphate 3400 g, Muriate of Potash and 2125 g Dolomite (Treatment 5) over the control (no fertilizer) and 43% nut yield increase in the recommended fertilizer (T_2 - 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 900 g, Imported Rock Phosphate by 625 g, Muriate of Potash by 1800 g and Dolomite by 1125 g (T_5) have shown the highest nut yield (52%) compared to the recommended dosage (T_2). The same experiment conducted at Naiwala site (WL_3 Boralu Series - S_4) has also shown significant increase ($p \leq 0.001$) of nut yield (124%) from the palms receiving 1700 g Urea, 1905 g Eppawala Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite - T_5) over the control (no fertilizer). The difference of nut yield between T_5 and recommended fertilizer (T_2) treated palms was 27%. This year i.e. six years after fertilizer application, these nut yield increases have shown particularly in Madampe, Wariyapola, Borupan and Boralu series soils in the Intermediate, Dry and Wet zones respectively and also four years after Kurunegala soil series in Intermediate zone. This study clearly showed that the recommended inorganic fertilizer dosages are not sufficient to give high yield of coconut.

The comparison of organic and green manure against inorganic fertilizer (APM-W) showed a 35% increase in the nut yield of the palms receiving poultry manure when compared to the control (no fertilizer). The yield increase by inorganic fertilizer over the control was 6%. The nut yield of poultry manure-treated palms was increased by 27% over inorganic fertilizer-treated palms. The nut yield increase by other organic sources such as cattle manure, goat manure and green manure (gliricidia) was 25%, 30% and 9% over the control respectively. As shown in previous years, the application of organic manure such as poultry manure, cattle manure and goat manure was economically more beneficial than inorganic fertilizers.

The experiment on effect of fertigation on coconut revealed nut yield increase of 31% by fertigation when compared to the control (no fertigation). The nut yield increase (8.5%) in fertilizer (Urea and Muriate of Potash) applied through drip irrigation system and Eppawala Rock Phosphate and Dolomite applied at the point of a drippers compared with above fertilizer applied on entire manual circle with drip irrigation treatments. The nut yield difference showed as 24% compared with only drip irrigation (no fertilizer) and fertigation.

As service functions, the Division provided Differential Fertilizer Recommendation (DFR) to 91 growers covering 2215 ha during the year. For quality testing 290 samples of inorganic fertilizer, 213 samples of organic manure, and 565 samples of coir pith were analyzed. In addition, soil survey and land suitability tests were completed for 25 growers covering a total extent of 1050 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 arranged in Randomized Block Design with 3 replicates and 6 palms per plot. It was established in 1991 and T x T seedlings were planted on Andigama series soils (Red Yellow Podzolic) at Ratmalagara Estate in IL_1 agro ecological region. The site falls into land suitability class S_4.

Treatments are given in Table 1.

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

Treatments	Rate of application g/palm/yr
T_1 - TSP (46% P_2O_5)	350
T_2 - IRP (27.5% P_2O_5)	600
T_3 - ERP (30% P_2O_5)	600
T_4 - 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 were collected from the 14th frond of each treated palm in June 2008. Fertilizer application was carried out in October. Nut yield data from October 2007 to September 2008 has not shown any significant difference among the treatments (Table 2).

Table 2: ***Nut yield of the experiment***

Treatment levels	Nut yield	
	2002 October to 2007 September Cumulative (nuts/palm)	2007 October to 2008 September (palm/year)
T_1 - TSP	256	72
T_2 - IRP	249	68
T_3 - ERP	245	69
T_4 - Control (No P sources)	212	63
Level of significance	* Only in 2005 October - 2006 September	ns
LSD ($p \leq 0.05$)	16.650 in 2005 October - 2006 September	-

Table 3 shows that the leaf P levels have shown significant differences ($p \leq 0.01$) between P sources and the control. Even though N and K levels were not significant, the levels of N and

K nutrients were above the critical levels (N > 1.9% and K > 1.2%). Leaf magnesium levels of the palms were below the critical levels (Mg > 0.25%)

Table 3: ***Nutrient concentration in the 14th frond***

Treatment levels	N%	P%	K%	Mg%
T_1 - TSP	2.13	0.17	1.77	0.24
T_2 - IRP	1.96	0.16	1.64	0.23
T_3 - ERP	1.99	0.16	1.71	0.23
T_4 - Control (No P source)	1.95	0.14	1.57	0.22
Level of significance	ns	**	ns	ns
LSD ($p \leq 0.05$)	-	0.014	-	-

Therefore, it was clearly proven that there was no significant difference in 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 of coconut soils in the Wet and Intermediate zones and this will lead to a substantial saving of foreign exchange.

After long-term (17 years) continuous application of IRP, ERP and TSP from the young palm stage, in this site, the accumulation of Cd in leaf, soil, kernel and nut water was analyzed this year. This study clearly showed that the Cd levels in soil, leaf, nut water, and kernel have not been increased up to contaminated levels but there is a tendency of Cd accumulation of in kernel of IRP treated palms than that of ERP treated palms (Table 4).

Table 4: ***Cd content of the 3 P sources***

Treatments	Soil mg/kg		Leaf	Kernel	Nut water
	(02 - 50) (cm)	(25- 50) (cm)	mg/kg	mg/kg	mg/l
TSP	0.008	0.010	0.191	0.082	negligible
IRP	0.004	0.001	0.093	0.186	negligible
ERP	0.021	0.009	0.035	0.160	negligible
Significance	ns	ns	ns	ns	

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Experiment 6.0.2: Effect of different phosphate sources on the performance of coconut seedlings in Southern soils - 2005

The experiment (Randomized Block Design with 3 replicates and 6 palms per plot) was established in December 2005 by planting T x SR seedlings in Katuwana soil series (Reddish Brown Latosols) at Middeniya sub station in IL_1 Agro Ecological Region. The site falls into land suitability class S_2 (Potential nut yield is 12,500 - 15,000 nuts/ha/yr). Treatments are given in Table 5.

Table 5: ***Treatments of the experiment***

Treatment Levels	6 m	1 yr	1 1/2 yrs	2 yrs	2 1/2 yrs	3 yrs	3 1/2 yrs	4 yrs up to bearing	After bearing
T_1 - No P source (Control)	-	-	-	-	-	-	-	-	-
T_2 - ERP	340	407	407	540	540	675	675	810	900
T_3 - IRP	225	270	270	360	360	450	450	540	600
T_4 - HERP	170	200	200	275	275	340	340	407	450
T_5 - 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 quantities of urea and muriate of potash in the basal mixture application were increased by 25% as T x SR is a high yielding variety and which prevented the N and K nutritional deficiency symptoms observed in seedlings.

The 4th and 5th (i.e. at the age of 2 and 2 ½ years) treatment applications were completed in March 2008 and September/October 2008. Leaf samples were collected before the application of treatments this year. The vegetative growth measurements i.e. girth of the 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 i.e. Leaf area ($p \leq 0.001$), girth of the stem ($p \leq 0.5$) and number of fronds ($p \leq 0.001$) have shown significant differences among the treatments, at the age of 2 years (Table 6).

Table 6: ***Vegetative growth measurements (Mean value of 18 palms)***

Treatments	Leaf area (cm^2)		Girth (cm)		Height (cm)		No of fronds in 2008	
	2 ½ yr	2 yr	2 ½ yr	2 yr	2 ½ yr	2 yr	2 ½ yr	2 yr
T1 - No P source	322792	157830	111	122	490	549	5	3
T2 - ERP	353090	191271	119	129	506	567	6	4
T3 - IRP	347039	169619	113	127	499	566	5	4
T4 - HERP	358730	165986	119	126	493	553	5	4
T5 - TSP	469156	214640	154	131	479	583	7	4
Level of significance	ns	***	ns	*	ns	ns	ns	***
LSD ($p \leq 0.05$)	-	27554	-	5.8991	-	-	-	0.4262

The leaf samples (i.e. 6th leaf) collected in March and September 2008 were analyzed for major nutrients as well as micro nutrients. Any of nutrients have not shown significant differences among the treatments, 2 and 2 ½ years after planting except P. (Tables 7 and 8)

Table 7: ***Nutrient concentrations of the palms at the age of 2 years***

Treatment	N	P	K	Mg	Ca	Fe	Mn	Cu	Zn
T_1	1.65	0.11	2.74	0.18	0.47	84.2	160.2	5.23	38.6
T_2	1.48	0.12	2.92	0.19	0.43	79.0	141.8	6.00	43.5
T_3	1.50	0.12	2.53	0.17	0.43	77.3	101.6	5.50	45.4
T_4	1.61	0.12	2.78	0.17	0.42	72.9	128.7	5.42	52.2
T_5	1.61	0.14	3.16	0.21	0.48	76.2	130.4	5.61	58.9
Level of significance	ns	**	ns	ns	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	0.0098	-	-	-	-	-	-	-

Table 8: ***Nutrient concentrations of the palms at the age of 2 ½ years***

Treatment	N	P	K	Mg	Ca	Fe	Mn	Cu	Zn
T_1	1.63	0.097	2.59	0.16	0.42	87.9	96.8	5.58	22.4
T_2	1.66	0.101	2.46	0.19	0.39	63.8	89.2	6.29	18.6
T_3	1.52	0.096	2.19	0.18	0.39	56.0	66.7	5.82	18.4
T_4	1.55	0.097	2.50	0.17	0.39	53.3	89.2	5.96	19.9
T_5	1.57	0.126	2.47	0.23	0.40	58.4	97.8	5.74	18.6
Level of significance	ns	**	ns	ns	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	0.0152	-	-	-	-	-	-	-

The soil samples were collected at two depths i.e. 0 - 20 and 20 - 40 cm in September 2008 (Table 9). Soil P at the depth of 0 - 20 cm ($p \leq 0.01$) and at the depth of 20 - 40 cm ($p \leq 0.05$) and magnesium at the depth of 0 - 20 cm ($p \leq 0.05$) have shown significant differences among the treatments.

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Table 9: ***Soil nutrient levels at Middeniya site***

Treatment	pH (1:5)		EC (µs/cm)		Total N (mg/kg)		Available P (mg/kg)		Exchangeable K		Exchangeable Mg		Exchangeable Ca		Exchangeable Na	
									◄ (meq/100g) ►							
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
T_1	6.49	6.33	102	99	770	770	2.43	1.57	0.92	0.86	2.41	2.94	5.87	7.16	0.03	0.02
T_2	6.62	6.52	82	71	1088	728	3.65	2.40	1.43	0.98	3.11	1.97	6.66	6.10	0.02	0.01
T_3	6.68	6.94	133	100	1167	938	4.84	3.10	1.06	1.05	2.61	2.85	7.43	6.69	0.02	0.01
T_4	6.66	6.45	83	87	1055	845	4.14	2.66	1.17	1.02	2.63	2.62	6.48	8.08	0.05	0.03
T_5	6.57	6.36	77	86	904	703	6.26	4.33	1.03	0.99	2.19	2.44	6.01	5.57	0.03	0.02
Level of Significance	ns	ns	ns	ns	ns	ns	**	*	ns	ns	*	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	-	-	-	-	-	1.6491	1.5724	-	-	0.5466	-	-	-	-	-

(I) Soil depth at 0 - 20 cm

(II) Soil depth at 20 - 40 cm

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

Experiment 7.0.2: Formulation of an effective fertilizer mixture for young coconut palms (2007)

The objectives of the experiment were

* To formulate an effective inorganic fertilizer mixture for young coconut palms.
* To formulate an effective package of organic manure for young coconut palms.
* To formulate the best inorganic/organic combination for young coconut palms.

Treatments combinations of the experiment have given in Table 10.

The experiment was Randomized Block Design with 3 replicates and six palms per plot. It was established in 2007 at the following locations.

Experiment No.	Location	Agro ecological Region	Soil Series	Land Suitability Class
7.0.2.1	Mangala Eliya	DL_1	Borupan series	S_2
7.0.2.2	Melsiripura	IL_3	Melsiripura series	S_2

Mangala eliya Site

Seedlings T x T were planted in March 2008. The growth parameters i.e. girth, height, leaf area and number of fronds were also recorded. The basal fertilizer (1 Kg of YPM - D + 1 Kg of Dolomite) was applied to all seedlings in June 2008. The soils samples were collected in March/April 2008.

Melsiripura Site

The seedlings Moroc tall were planted in June 2008. The growth parameters i.e. girth, height, leaf area and number of fronds were also recorded. The basal fertilizer (1 Kg of YPM - D + 1 Kg of Dolomite) was applied in December 2008. The soils samples were collected in June/July 2008.

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Table 10: ***Treatment combinations of he experiment***

		6 months	1 year	1 ½ years	2 years	2 ½ years	3 years	3 ½ years	4 yrs up to bearing
YPM - L_1	Urea (g)	150	180	180	240	240	300	300	360
	ERP (g)	340	405	405	540	540	675	675	810
	MOP (g)	150	180	180	240	240	300	300	360
	Dolomite (g)	500	500	500	500	500	500	500	500
YPM - L_2	Urea (g)	225	270	270	360	360	450	450	540
	ERP (g)	510	608	608	810	810	1013	1013	1215
	MOP (g)	225	270	270	360	360	450	450	540
	Dolomite (g)	750	750	750	750	750	750	750	750
YPM - L_3	Urea (g)	300	360	360	480	480	600	600	720
	ERP (g)	680	810	810	1080	1080	1350	1350	1620
	MOP (g)	300	360	360	480	480	600	600	720
	Dolomite (g)	1000	1000	1000	1000	1000	1000	1000	1000
Goat manure + Inorganic - L_1	GM (g)	3	7	-	9	-	11	-	13
	ERP (g)	200	450	-	600	-	750	-	1000
	MOP (g)	50	120	-	150	-	190	-	225
	Dolomite (g)	250	250	-	250	-	250	-	250
Goat manure + Inorganic - L_2	GM (g)	4.5	10.5	-	13.5	-	16.5	-	19.5
	ERP (g)	300	675	-	900	-	1125	-	1500
	MOP (g)	75	180	-	225	-	285	-	337
	Dolomite (g)	375	375	-	375	-	375	-	375
Goat manure + Inorganic - L_3	GM (g)	6	14	-	18	-	22	-	26
	ERP (g)	400	900	-	1200	-	1500	-	2000
	MOP (g)	100	240	-	300	-	380	-	450
	Dolomite (g)	500	500	-	500	-	500	-	500
Goat manure + Organic - L_1	GM (g)	3	7	-	9	-	11	-	13
	ERP (g)	200	450	-	600	-	750	-	1000
	Dolomite (g)	250	250	-	250	-	250	-	250
	Husk	8	18	-	22	-	30	-	40

Contd.

Contd.

		6 months	1 year	1 ½ years	2 years	2 ½ years	3 years	3 ½ years	4 yrs up to bearing
Goat manure + Organic - L_2	GM (g)	4.5	10.5	-	13.5	-	16.5	-	19.5
	ERP (g)	300	675	-	900	-	1125	-	1500
	Dolomite (g)	375	375	-	375	-	375	-	375
	Husk	12	27	-	33	-	45	-	60
Goat manure + Organic - L_3	GM (g)	6	14	-	18	-	22	-	26
	ERP (g)	400	900	-	1200	-	1500	-	2000
	Dolomite (g)	500	500	-	500	-	500	-	500
	Husk	16	36	-	44	-	60	-	80
Gliricidia + Inorganic - L_1	Gliricidia (kg)	5	12	-	16	-	20	-	23
	ERP (g)	275	650	-	825	-	1100	-	1350
	MOP (g)	60	150	-	200	-	250	-	300
	Dolomite (g)	250	250	-	250	-	250	-	250
Gliricidia + Inorganic - L_2	Gliricidia (kg)	7.5	18	-	24	-	30	-	35
	ERP (g)	413	975	-	1238	-	1650	-	2025
	MOP (g)	90	225	-	300	-	325	-	450
	Dolomite (g)	375	375	-	375	-	375	-	375
Gliricidia + Inorganic - L_3	Gliricidia (kg)	10	24	-	32	-	40	-	46
	ERP (g)	550	1300	-	1650	-	2200	-	2700
	MOP (g)	120	300	-	400	-	400	-	600
	Dolomite (g)	500	500	-	500	-	500	-	500
Gliricidia + Organic - L_1	Gliricidia (kg)	5	12	-	16	-	20	-	23
	ERP (g)	275	650	-	825	-	1100	-	1350
	Husk	8	18	-	22	-	30	-	40
	Dolomite (g)	250	250	-	250	-	250	-	250
Gliricidia + Organic - L_2	Gliricidia (kg)	7.5	18	-	24	-	30	-	35
	ERP (g)	413	975	-	1238	-	1650	-	2025
	Husk	12	27	-	33	-	45	-	60
	Dolomite (g)	375	375	-	375	-	375	-	375
Gliricidia + Organic - L_3	Gliricidia (kg)	10	24	-	32	-	40	-	46
	ERP (g)	550	1300	-	1650	-	2200	-	2700
	Husk	16	36	-	44	-	60	-	80
	Dolomite (g)	500	500	-	500	-	500	-	500

Experiment 7.0.3: Determination of critical levels of nutrients in young coconut palms of Sri Lanka (2008)

The objectives of the experiment were

* To assess the macro and micro nutrient status in young coconut palm.
* To select the suitable frond for nutrient analysis in young coconut palm.
* To identify any nutrient disorders according to the age of the palm.

At least 100 sites have to be selected for the leaf sampling. Leaf samples will be collected according to the age i.e. from 1st year, 2nd year, 3rd year and 4th year upto bearing stages in different land suitability classes and representing different agro ecological regions. Leaf samples will be colleted separately according to the frond number. Table 11 indicates the number of fronds selected in each year for leaf sampling.

Table 11: ***Number of fronds selected in each year for leaf sampling***

Age	Leaf Rank														
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
1 year	✓	✓	✓	✓	✓										
2 year	✓	✓	✓	✓	✓	✓	✓	✓							
3 year	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
4 year up to bearing stage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

In year 2008, a total of 20 sites were selected, 11 from Marawila and 9 from Gampaha Region respectively.

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PROJECT 7.1: IMPROVEMENT OF DIFFERNTIAL 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 dose 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 suitability classes to fertilizer doses that are higher than the generally recommended dose and in relation to data on soil, plant and fertilizer rates to develop recommendation criteria for coconut palms in high potential lands.

The experimental design was 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	DL_1	Borupan series	2000	S_2
7.1.2.2	Naiwala	WL_3	Boralu series	2002	S_4
7.1.2.3	Kobeigana	IL_1	Wariyapola series	2002	S_3
7.1.2.4	Sirigampola	IL_1	Madampe series	2002	S_1
7.1.2.5	Wellawa	IL_1	Kurunegala series	2003	S_2

The treatments for all the sites are given in Table 12.

Table 12: ***Treatment combinations of the experiment (g/palm/yr)***

Treatments	Urea	IRP/ERP	MOP	Dolomite
T_1	0	0	0	0
T_2	800	600 / 900	1600	1000
T_3	1100	825/1235	2200	1375
T_4	1400	1070/1570	2800	1750
T_5	1700	1225/1907	3400	2125

7.1.2.1: Mangala Eliya site

The nut yield of the experiments are given in Table 13.

Table 13: ***The nut yield of Mangala-eliya site***

Treatment	Cumulative nut yield (nuts/palm) 2001 Sept. to 2007 Aug.	Nut yield (palm/year) 2007 Sept. to 2008 Oct.
T_1	488	62
T_2	606	89
T_3	635	86
T_4	673	115
T_5	605	135
Level of Significance	* in (2003/ 2004) ** in (2005/ 2006) *** in (2006/ 2007)	**
LSD ($P \leq 0.050$)	13 (2003/ 2004) 15 (2005/ 2006) 11 (2006/ 2007)	18

A significant increase ($p \leq 0.01$) in nut yield (117%) was observed from those palms receiving 1700 g urea, 1225 g Imported Rock Phosphate, 3400 g Muriate of Potash and 2125g Dolomite (T_5) over control (no fertilizer) and 43% nut yield increase was observed in the recommended fertilizer treated palms (T_2) - 800 g Urea, 600 g Imported Rock Phosphate, 1600 g Muriate of Potash and 1000 g Dolomite over control.

Increase of urea by 900 g, Imported Rock Phosphate by 625 g, Muriate of Potash by 1800 g and Dolomite by 1125 g have shown the highest nut yield by 52% increase compared to the recommended dosage (T_2). This year i.e. 8 years after fertilizer application, this nut yield increase was shown particularly by Borupan soil series (S_2) in the Dry zone where the site is located. It is clearly showed that coconut plantation at high fertile soils i.e. S_2, the supply of nutrients have to be increased by 1.5 to 2 times compared with general recommendation, due to high removal of nutrients and high yield.

The leaf sampling was completed in May 2008. All the leaf nutrients were in the sufficiency range ($N \geq 1.9\%$, $P \geq 0.11\%$, $Mg \geq 0.25\%$) except N and K in control plots. The K levels have increased this year compared to last year (Table14). When considering K and Mg, in the palms having low K content, the Mg levels were shown high levels due to K & Mg antagonism interaction. This trend was seen in all treated palms.

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

Treatments	N%	P%	K%	Mg%
T_1	1.88	0.12	0.99	0.31
T_2	1.90	0.12	1.22	0.27
T_3	1.92	0.12	1.22	0.28
T_4	1.96	0.12	1.20	0.28
T_5	1.96	0.12	1.23	0.26
Level of Significance	ns	ns	ns	ns

Soil samples were collected in May 2008. The soil nutrient values of the treatment applied soils are given in Table 15.

The nutrients of K ($p \leq 0.01$), Ca ($p \leq 0.05$) and P ($p \leq 0.01$) at the depth of 20 - 40 cm and Ca ($p \leq 0.01$) and P ($p \leq 0.001$) at the depth of 0 - 20 cm have shown significant differences among the treatments. The pH ($p \leq 0.001$) at the depth 0 - 20 cm and 20 - 40 cm and electrical conductivity ($p \leq 0.01$) at the depth 20 - 40 cm have also shown significant differences among the treatments.

Table 15: ***Soil nutrient levels at Mangala-eliya site***

Treatment	pH (1:5)		EC (µs/cm)		N		P		K		Mg		Ca		Na	
					◄ (mg/kg) ►				◄ (meq/100g) ►							
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
T_1	5.84	5.54	35	23	181	97	118	29	0.15	0.08	1.75	2.32	1.12	0.53	0.20	0.21
T_2	6.22	5.89	39	33	190	106	331	65	0.21	0.17	2.93	1.38	1.96	0.49	0.21	0.21
T_3	6.37	6.16	44	39	194	97	394	86	0.22	0.21	2.57	2.02	1.70	0.95	0.22	0.05
T_4	6.44	6.30	47	40	190	132	465	136	0.25	0.31	2.00	1.09	1.83	0.84	0.25	0.08
T_5	6.50	6.30	42	41	221	101	489	127	0.26	0.29	1.92	1.70	1.93	0.75	0.19	0.01
Level of Significance	***	***	ns	**	ns	ns	***	**	ns	**	ns	ns	**	*	ns	ns
LSD ($p \leq 0.05$)	0.1023	0.1067	-	9.7297	-	-	76.526	53.795	-	0.968	-	-	0.4501	0.1211	-	-

(I) Soil depth at 0 - 20 cm

(II) Soil depth at 20 - 40 cm

Experiment 7.1.2.2 - Naiwala

A significant increase ($p \leq 0.001$) in nut yield (124%) was observed in the palms receiving 1700 g Urea, 1907 g Eppawela Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over control (no fertilizer) and 27% increase in nut yield was observed over recommended fertilizer applied palms (T_2 - Urea 800 g, Eppawela Rock Phosphate 900 g, Muriate of Potash 1600 g and Dolomite 1000 g) 4 years after imposement of fertilizer treatment (Table 16). The nut yield was increased by 27% compared with T_5 and T_2.

Table 16: ***The nut yield of the Naiwala site***

Treatment	Cumulative Nut Yield (nuts/palm) 2003 November to 2007 October	Nut Yield (palm/year) 2007 November to 2008 October
T_1	146	29
T_2	213	51
T_3	212	50
T_4	228	55
T_5	234	65
Level of significant	** in 2004/ 2005 *** in 2005/ 2006 *** in 2006/ 2007	***
LSD ($p \leq 0.05$)	08 in 2004/ 2005 08 in 2005/ 2006 10 in 2006/ 2007	09

The leaf samples were collected in October 2008. Only P has shown significant differences among the treatments (Table 17). In general leaf nutrient levels (N, K and Mg) were below the critical levels except P, N and K of T_4 and T_5.

Table 17: ***Leaf nutrient levels of the Naiwala Site***

Treatment	N %	P %	K %	Mg
T_1	1.87	0.12	0.97	0.13
T_2	1.89	0.13	1.05	0.14
T_3	1.89	0.14	1.08	0.16
T_4	1.97	0.13	1.23	0.16
T_5	2.03	0.13	1.23	0.16
Level of significance	ns	*	ns	ns
LSD ($p \leq 0.050$)	-	0.010	-	-

Experiment 7.1.2.3 - Kobeigane

The site at Kobeigane has shown 51% 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 13% nut yield increase in the treatment receiving recommended dosage of fertilizer (T_2) over the control. This year i.e. five years after fertilizer application, significant nut yield increase has shown particularly in Wariyapola series soil in the Intermediate zone (Table 18). The nut yield increased by 34% compared with T_4 and T_2.

Table 18: ***Nut yield of the Kobeigane experimental site***

Treatment	Cumulative nut yield (nuts/palm) 2003 November - 2007 October	Nut yield (palm/year) 2007 November - 2008 October
T_1	255	47
T_2	285	53
T_3	320	67
T_4	378	71
T_5	354	69
Level of significant	** in 2004/ 2005 and * in 2005/ 2006 ** in 2006/ 2007	**
LSD ($p \leq 0.05$)	16 in 2004/ 2005 and 14 in 2005/ 2006 11 in 2006/ 2007	14

The leaf samples were collected in October 2008 and results are given in Table 19. Leaf nutrients have shown above the critical level in treated palms except N and K in control palms. The K and Mg antagonism interaction appeared in this site as well. The leaf nutrient levels were not significant except P.

Table 19: ***Leaf nutrient levels at Kobeigane site***

Treatments	N %	P %	K %	Mg %
T_1	1.81	0.13	1.11	0.30
T_2	1.92	0.12	1.20	0.29
T_3	1.95	0.13	1.20	0.28
T_4	1.97	0.14	1.27	0.26
T_5	2.03	0.14	1.27	0.26
Level of significant	ns	*	ns	ns
LSD ($p \leq 0.05$)	-	0.004	-	-

Experiment 7.1.2.4 - Sirigampola

The site at Sirigampola has shown 87% significant increase ($p \leq 0.001$) in nut yield from the palms receiving 1700 g Urea, 1907 g Eppawela Rock Phosphate, 3400 g Muriate of Potash and 2125 g Dolomite (Treatment 5) over control (no fertilizer) and 34% nut yield increase in the treatment received recommended fertilizer (T_2) over the control (Table 20). Yield increase was shown by 39% compared with T_5 and T_2.

Table 20: ***Nut yield of the Sirigampola Site***

Treatment	Cumulative nut yield (nuts/palm) 2003 November - 2006 October	Nut yield (palm/year) 2006 November - 2007 October
T_1	256	53
T_2	307	71
T_3	326	75
T_4	343	90
T_5	372	99
Level of significant	** in 2004/2005 and *** in 2005/2006 * in 2006/2007	*
LSD ($p \leq 0.05$)	14 in 2004/2005 and 13 in 2005/2006 22 in 2006/2007	20

The leaf samples were collected in September 2008. Leaf nutrient values have not shown significant differences among the treatments except leaf Mg. However the leaf nutrient levels were above the critical levels except K levels in control (T_1), (T_2) and (T_3) treated palms. The antagonism interaction of K and Mg is evident in this site as well (Table 21).

Table 21: ***Nutrient level of the 14th frond at Sirigampola site***

Treatment	N %	P %	K %	Mg %
T_1	2.16	0.14	0.50	0.38
T_2	2.17	0.15	0.93	0.33
T_3	2.23	0.14	0.97	0.27
T_4	2.27	0.14	1.33	0.27
T_5	2.28	0.14	1.34	0.25
Level of significant	ns	ns	ns	***
LSD ($p \leq 0.05$)	-	-	-	0.049

The soil samples collected in October 2007 were analyzed and results are given in Table 22. Soil nutrients such as P, K, Mg and Ca at soil depth 0 - 20 cm and K at soil depth 20 - 40 cm have shown significant difference among the treatments. Soil pH at 0 - 20 cm soil depth and EC at both depths have also shown significant differences among the treatments.

Table 22: ***Soil nutrient levels at Sirigampola site***

Treatment	pH (1:5)		EC (µs/cm)		N		P		K		Mg		Ca		Na	
					◄ (mg/kg) ►				◄ (meq/100g) ►							
	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)	(I)	(II)
T_1	5.03	4.55	35	26	251	52	88	28	0.09	0.04	0.54	0.21	1.46	0.58	0.04	0.02
T_2	5.76	4.68	87	56	266	99	136	54	0.60	0.27	0.71	0.36	2.20	0.88	0.05	0.04
T_3	6.04	4.72	95	62	358	70	190	25	0.74	0.31	0.89	0.34	2.67	0.78	0.07	0.06
T_4	6.24	4.69	103	89	236	35	253	39	1.00	0.49	0.98	0.36	3.49	0.87	0.08	0.05
T_5	6.37	4.75	245	136	312	35	319	55	1.70	0.75	1.15	0.45	4.12	1.09	0.09	0.14
Level of Significance	**	ns	**	*	ns	ns	*	ns	***	**	*	ns	*	ns	ns	ns
LSD ($p \leq 0.05$)	0.4568	-	84.017	56.689	-	-	150.56	-	0.4837	0.298	0.3161	-	1.4073	-	-	-

(I) Soil depth at 0 - 20 cm

(II) Soil depth at 20 - 40 cm

Experiment 7.1.2.5 - Wellawa

The nut yield has shown a significant difference ($p \leq 0.001$) among the treatments this year (Table 23). The results clearly showed that nut yield was increased as 60% from palms which received 1400 g Urea, 1570 g ERP, 2800 g MOP and 1750 g Dolomite (T_4)over the control (no fertilizer). Only 7% nut yield was increased between T_4 and T_2 (Recommended fertilizer mixture).

Table 23: ***Nut yield of the experiment at Wellawa Site***

Treatment	Cumulative nut yield (nuts/palm) 2003 November - 2007 October	Nut yield per (palm/year) 2007 November - 2008 October
T_1	201	45
T_2	218	55
T_3	223	65
T_4	226	72
T_5	226	67
Level of significant	* in 2006/ 2007	***
LSD ($p \leq 0.05$)	8 in 2006/ 2007	12

Leaf nutrient levels have given in Table 24 and the nutrients have not shown significant differences among the treatments except leaf N. In general, all nutrients are in the range of critical level except the nutrients in the control palms.

Table 24: ***Nutrient levels of the Wellawa site***

Treatment	N %	P %	K %	Mg %
T_1	1.83	0.11	0.86	0.19
T_2	1.90	0.12	1.26	0.25
T_3	1.95	0.12	1.32	0.25
T_4	2.02	0.12	1.28	0.25
T_5	1.93	0.12	1.20	0.25
Level of significant	*	ns	ns	ns
LSD ($p \leq 0.05$)	0.1295	-	-	-

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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 (2005)

The aim of this experiment was to quantify the removal of some micronutrients from coconut palms growing in moderately suitable (S_4) and highly suitable (S_1) land classes.

The experiment on land suitability class S_4 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 were determined at monthly intervals. The components were analyzed for N, P, K, Ca, Mg, S, Cl, B, Fe, Cu, Zn, and Mn. The full year data were given in 2007 Annual Report.

The data can be used in determining the pattern and the level of micronutrient as well as macronutrient removed by the coconut palm which belongs to S_4 land suitability class.

This experiment was terminated in January 2008.

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Experiment 7.2.3: Determination of heavy metals in nut water and kernel after long-term application of organic manure (2007)

The objective of the experiment was to assess the accumulation of heavy metals in nut water, kernel and leaf of the coconut palm and coconut soil after long-term application of organic manure.

The samples were taken from the on-going experiment on comparison of organic manure and inorganic fertilizer for coconut palm at Rathmalagara. This was established in 1997.

The samples were handed over to ITI for the determination of heavy metals.

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Experiment 7.2.4: Studies on Zn & Cu chelates on micronutrient sources for coconut (2007).

The objective of the experiment was to determine Zn and Cu nutrient levels in coconut seedlings due to application of Zn and Cu chelates to the soil and effect of Zn and Cu on the growth of coconut.

Twenty one large buckets (pots) were selected for this experiment and the design of experiment was complete Randomized Block Design with 3 replicates. Soils were selected from Madampe soil series and 80 kg of soils were filled to each bucket. Planting of coconut seedlings has been completed and treatment application was not done due to unavailability of the chemicals i.e. Cu EDTA and Zn EDTA. Therefore it was decided to discontinue this experiment for a while until the chemicals become available.

M K F Nadheesha, N A Tennakoon, N H R M de Silva & F H A J R Silva

Experiment 7.2.5: Evaluation of suitable Zn and Cu source for young coconut palms

The objective of the experiment was to study the effect of Cu and Zn on growth of coconut palms from seedling stage to bearing stage. Two sites were selected from Horakelle estate in Marawila to represent the Madampe series soils (S_2) in IL1 agro ecological zone. This experiment design was Randomized Complete Block Design with 3 replicates and six seedlings per plot. Treatments of the experiment are given in Tables 25 and 26.

Table 25: ***Treatment combinations of the Zn experiment***

T_1	Control (No Zn and Cu)
T_2	Soil application of 30 g $ZnSO_4$
T_3	Soil application of 30 g $ZnSO_4$ + 30 g $CuSO_4$
T_4	Spraying of 0.3 % $ZnSO_4$ solutions
T_5	Spraying of 0.3 % $ZnSO_4$ + solutions 0.3 % $CuSO_4$
T_6	Soil application of 30 g ZnEDTA
T_7	Soil application of 30 g ZnEDTA + 30 g CuEDTA
T_8	Spraying of 0.3 % ZnEDTA
T_9	Spraying of 0.3 % ZnEDTA + 0.30 % CuEDTA
T_{10}	Axil feeding of 30 g $ZnSO_4$
T_{11}	Axil feeding of 30 g $ZnSO_4$ + 30 g $CuSO_4$
T_{12}	Axil feeding of 30 g ZnEDTA
T_{13}	Axil feeding of 30 g ZnEDTA + 30 g CuEDT

All the plots will be treated with a basal doze of Young Palm Mixture + Dolomite at every six months with each treatment. Preliminary soil sampling was completed. The experiment was not continued due to financial constraints.

Table 26: ***Treatment combinations of the Cu experiment***

T_1	Control (No Zn and Cu)
T_2	Soil application of 30 g $CuSO_4$
T_3	Soil application of 30 g $CuSO_4$ + 30 g $ZnSO_4$
T_4	Spraying of 0.3 % $CuSO_4$ solutions
T_5	Spraying of 0.3 % $CuSO_4$ + solutions 0.3 % $ZnSO_4$
T_6	Soil application of 30 g CuEDTA
T_7	Soil application of 30 g CuEDTA + 30 g ZnEDTA
T_8	Spraying of 0.3 % CuEDTA
T_9	Spraying of 0.3 % CuEDTA + 0.30 % ZnEDTA
T_{10}	Axil feeding of 30 g $CuSO_4$
T_{11}	Axil feeding of 30 g $CuSO_4$ + 30 g $ZnSO_4$
T_{12}	Axil feeding of 30 g CuEDTA
T_{13}	Axil feeding of 30 g CuEDTA + 30 g ZnEDTA

D M D I Wijebandara & N A Tennakoon

Experiment 7.2.6: Study the different axil feeding methods on increase of leaf Cu and Zn levels of coconut leaves

The objective of the experiment was to evaluate the suitable method of application of Cu and Zn which can increase the Cu and Zn concentrations in coconut palm. The experimental design was Randomized Complete Block Design, including 6 palms per plot with 3 replicates. Treatments are given in Table 27.

Table 27: ***Treatment combinations of the experiment***

T_1	Control (No Zn and Cu)
T_2	Axil feeding of 10 g of $ZnSO_4$. $7H_2O$ without damaging the petiole
T_3	Axil feeding of 10 g of $ZnSO_4$. $7H_2O$ damaging the petiole
T_4	Axil feeding of 10 g of $ZnSO_4$. $7H_2O$ through a cut in petiole
T_5	Axil feeding of 10 g of CuO_4. $7H_2O$ without damaging the petiole
T_6	Axil feeding of 10 g of $ZnSO_4$. $7H_2O$ damaging the petiole
T_7	Axil feeding of 10 g of $ZnSO_4$. $7H_2O$ through a cut in petiole

Preliminary studies were conducted to test the maximum concentration of Cu and Zn nutrients which can be fed through the axil.

D M D I Wijebandara & N A Tennakoon

Experiment 7.2.7: Study the response of Cu and Zn nutrients on embryo cultured coconut

The objective of the laboratory experiment was to study the effect of Cu and Zn on embryo germination and subsequent growth of plants raised under in vitro conditions. Embryos of the variety Sri Lanka Tall cultured in media with different concentrations of Cu and Zn and incubated under controlled light and temperature conditions. The experimental design was Complete Randomized Design with 10 replicates and four sets for each treatment. The treatments of the experiment are given in Table 28.

Table 28: ***Treatments of the experiment***

T_1	Control (No Zn and Cu)
T_2	Standard culture media (25 µM $ZnSO_4.7H_2O$ +1.0 µM $CuSO_4.5H_2O$)
T_3	Higher Zn level (50 µM $ZnSO_4.7H_2O$) + Standard Cu level (1.0 µM $CuSO_4.5H_2O$)
T_4	Lower Zn level (12.5 µM $ZnSO_4.7H_2O$) + Standard Cu level (1.0 µM $CuSO_4.5H_2O$)
T_5	Standard Zn level (25 µM $ZnSO_4.7H_2O$) + Higher Cu level (2.0 µM $CuSO_4.5H_2O$
T_6	Standard Zn level (25 µM $ZnSO_4.7H_2O$) + Lower Cu level (0.5 µM $CuSO_4.5H_2O$

Data recording was commenced one month after culture initiation. Initially, the number of germinated embryos was recorded. The height, number of leaves and number of roots (primary and secondary) of each plant were recorded later on.

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Experiment 7.2.8: Study the response of Cu and Zn nutrients on germination of coconut seed nuts

A nursery experiment was initiated to test the response of Cu and Zn nutrients on germination of coconut seed nuts. Selected nuts (TxT) were treated with ten different Cu and Zn treatments and laid out in a nursery. The experiment was in Completely Randomized Block Design with 20 replicates. Treatment combinations are given in Table 29.

Table 29: ***Treatment combinations of the experiment***

T_1	Control (No Zn and Cu)
T_2	12.5 µM $ZnSO_4$ solution
T_3	0.5 µM $CuSO_4$ solution
T_4	12.5 µM $ZnSO_4$ + 0.5 µM $CuSO_4$ solution
T_5	25 µM $ZnSO_4$ solution
T_6	1.0 µM $CuSO_4$ solution
T_7	25 µM $ZnSO_4$ + 1.0 µM CuSO4 solution
T_8	50 µM $ZnSO_4$ solution
T_9	2.0 µM $CuSO_4$ solution
T_{10}	50 µM $ZnSO_4$ + 2.0 µM $CuSO_4$ solution

One month after laying, the number of geminated seed nuts were recorded every week

D M D I Wijebandara, T R Gunathilaka & A A F L K Perera

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 (K/Mg) 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 experimental design was Complete Randomized Block Design (with single palm replicate with four treatments, four palms per block, 3 replicates per group with six groups) and it was established in 2002 at Bandirippuwa Estate.

Location	Agro-ecological Region	Soil type	Land suitability class
Bandirippuwa Estate	IL_1	Gravel (Boralu series)	S_4

Treatment combinations are given in Table 30.

Table 30: ***Treatment combinations of the experiment***

	Application rate (palm/year)
T_1	3 kg APM (MOP 1600 g + Urea 800 g + ERP 900 g)
T_2	3 kg APM + 1 kg Kieserite
T_3	3 kg APM + 1 kg Kieserite (6 months later)
T_4	Urea 800 g + ERP 900 g + MOP 1600 g - ½ circle MOP Kieserite 1 kg - ½ circle Kieserite

Nut yield of this experiment during the period of October 2007 to September 2008 have shown a significant difference ($p \leq 0.05$) among the treatments. (Table 31). The palms receiving treatments 3 and 4 have shown higher nut yields compared to treatments 1 and 2. The nutrients K and Mg supplied as MOP and Kieserite by ½ circle separately has given the highest nut yield compared to other treatments.

Table 31: ***Nut and female flower production of the treated palms***

Treatment	Nut yield (palm/yr) (Oct. 2006 to Sept. 2007)	Nut yield (palm/yr) (Oct. 2007 to Sept. 2008)
T_1	39	67
T_2	45	66
T_3	56	80
T_4	53	91
Level of Significance	ns	*
LSD ($p \leq 0.05$)	-	16.81

Leaf samples were collected in June 2008 and the leaf nutrient levels of 14th leaf are given in Table 32. The nutrients have not shown significant differences among the treatments this year. However, the major nutrients such as N, P, K and Mg are in the sufficiency range.

Table 32: ***Leaf nutrient levels of the experiment***

Treatment	N %	P %	K %	Mg %	Ca %
T_1	2.09	0.13	1.38	0.26	0.53
T_2	1.92	0.13	1.28	0.26	0.47
T_3	2.03	0.14	1.39	0.25	0.45
T_4	2.08	0.14	1.48	0.25	0.48
Level of Significance	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	-	-	-	-

M K F Nadheesha, N A Tennakoon, S Sabaratnam, K J S Perera & W Gunasena

Experiment 9.0.3: Behavior of urea and dolomite in dry zone high pH soil. (2007)

A field experiment was designed to study the availability of nitrogen from urea and availability of magnesium from dolomite in high pH dry zone soils based on the results obtained from a green house experiment conducted in 2006.

Two locations were selected and the details are given in Table 33.

Table 33: ***Details of the locations.***

Location	AER	Soil Type	Land suitability class
Anuradhapura	DL_1	Reddish Brawn Earth and Law Humic Gley	S_3
Maduru Oya	DL_2	Reddish Brawn Earth	S_3 - S_4

The design of the experiment was Randomized Block Design with 3 replicates. Each plot has six effective palms.

Treatment combinations are given in Table 34.

Table 34: ***Treatment combinations of the experiment.***

T_1	Control (only basal application)
T_2	Dolomite 1000 g palm/ yr
T_3	Urea 800 g palm/ yr
T_4	Ammonium sulphate 1750 g palm/ yr
T_5	Dolomite + Urea (Combination of $T_2 + T_3$)
T_6	Dolomite + Ammonium sulphate (Combination of $T_2 + T_4$)

Basal dose - IRP 600 g + MOP 1600 g palm/ yr

The 1st treatment application was completed at both sites in December 2008. Preliminary soil and leaf samples were collected and the data are given in Tables 35 and 36 for Anuradhapura and Melsiripura sites respectively.

Table 35: ***Leaf nutrient levels of the 14th frond at Anuradhapura site***

Treatment	N %	P %	K %	Mg %	Ca	Ni	S
T_1	2.08	0.15	0.65	0.62	0.56	0.42	0.10
T_2	2.22	0.16	0.72	0.58	0.55	0.45	0.09
T_3	2.14	0.16	0.76	0.55	0.55	0.42	0.10
T_4	1.98	0.15	0.76	0.51	0.54	0.46	0.11
T_5	2.13	0.16	0.69	0.58	0.60	0.44	0.11
T_6	1.95	0.15	0.68	0.55	0.55	0.47	0.09

Table 36: ***Leaf nutrient levels of the 14th frond at Maduruoya site***

Treatment	N %	P %	K %	Mg %	Ca	Ni	S
T_1	2.13	0.15	1.41	0.32	0.55	0.14	0.10
T_2	2.03	0.14	1.43	0.32	0.55	0.13	0.10
T_3	2.14	0.14	1.29	0.34	0.55	0.13	0.10
T_4	2.09	0.14	1.50	0.32	0.55	0.10	0.08
T_5	2.17	0.15	1.39	0.33	0.54	0.14	0.11
T_6	2.28	0.15	1.47	0.30	0.54	0.10	0.11

H M I K Herath, L R M C Liyanage, N A Tennakoon, U S S Perera, B S V J Perera, E M A T Banda, N H R M de Silva & F H A J R Silva

Experiment 9.0.4: Alternative sources capable of supplying potassium for coconut: Green House Experiment (2007)

The treatments of the green house experiment are given in Table 37.

Table 37: ***Treatments and the amount of Potassium added from different sources***

Treatment	Material	Amount (g)/ 5kg soil of pot as L_1
T_1	Control - No natural source	-
T_2	Mica (powder)	26 g
T_3	Feldspar (powder)	24 g
T_4	Coconut husk ash	12 g
T_5	Tithonia (wild sun flower)	70 g
T_6	Locally produced K fertilizer	20 g
T_7	Muriate of Potash (MOP)	04 g

L_2 - Double the rates

Soil pH of treatment at level one (L_1) shows that soil pH has increased with the application of treatments. Among all the treatments, husk ash, locally produced K fertilizer and Tithonia treatments have increased the pH to a neutral range (6.5 - 7.5) up to 3 months. Then Tithonia treatment showed a gradual reduction while in the other two treatments, the pH remains above 6.5 with some fluctuations. MOP, mica and feldspar applied treatments did not show a significant difference with the control. Soil pH of those treatments were below 5 (Fig 1).

When level 2 (L_2) of the treatments are considered, both coconut husk ash and locally produced K fertilizer treatments increased soil pH between 8 - 10 which is not suitable for the availability of most of other nutrients. Tithonia level 2 incorporated pots showed a pH around 6 during the experimental period. Mica, feldspar and MOP treatments showed a pH between 4 - 5 irrespective of the rate of application and these treatments did not show a significant difference among them and with the control (Fig 2).

Soil exchangeable K levels of the soils incorporated with different treatments are given in Figs 3 and 4. Highest exchangeable K levels were given by husk ash and locally produced K fertilizer treatments in 4, 7, 8, 9 months after application of treatments level 1 (IL_1) Locally produced K fertilizer showed a significantly higher exchangeable K level than all the other treatments in 1, 2 and 3 months. Those two treatments showed significantly higher K levels than MOP in both level 1 and 2.

Mica and feldspar showed very low (less than 0.3 meq/100 g soil) level of K in soil showing very slow releasing and the increase in K level with time was very slow. These two treatments did not show a significant difference with the control. Significantly lower K levels were observed in level 1 and 2 of mica, feldspar and control through out the experimental period.

Tithonia applied treatment showed a higher exchangeable. K than control, mica and feldspar and lower than husk ash, locally produced K fertilizer and MOP. (1 - 1.8 meq/100g in level 1 and 1 - 3.6 meq/100g soil in level 2).

However, by the 9 month, all the other treatments except mica, feldspar and control, K level 1 has come to a value closer to 1 meq/100g soil irrespective of level of application.

Exchangeable Mg levels did not show a specific pattern of changing. However, significantly higher soil Mg were given by husk ash, locally produced K fertilizer and Tithonia applied treatments and the same pattern could be observed in level 1 and level 2 (Figs 5 and 6).

By the 8^{th} and 9^{th} month highest exchangeable Mg was observed in locally produced K fertilizer treated soils in both levels 1 and 2.

In level 2 treatments, Tithonia applied treatments showed significantly higher exchangeable Mg than normal husk ash in 7, 8 and 9 month after incorporation but lower than locally produced K fertilizer treated soil.

Experiment is in progress with analysis on uptake of nutrients with an indicator plant using the same set of treatments.

H M I K Herath, N A Tennakoon & U S S Perera

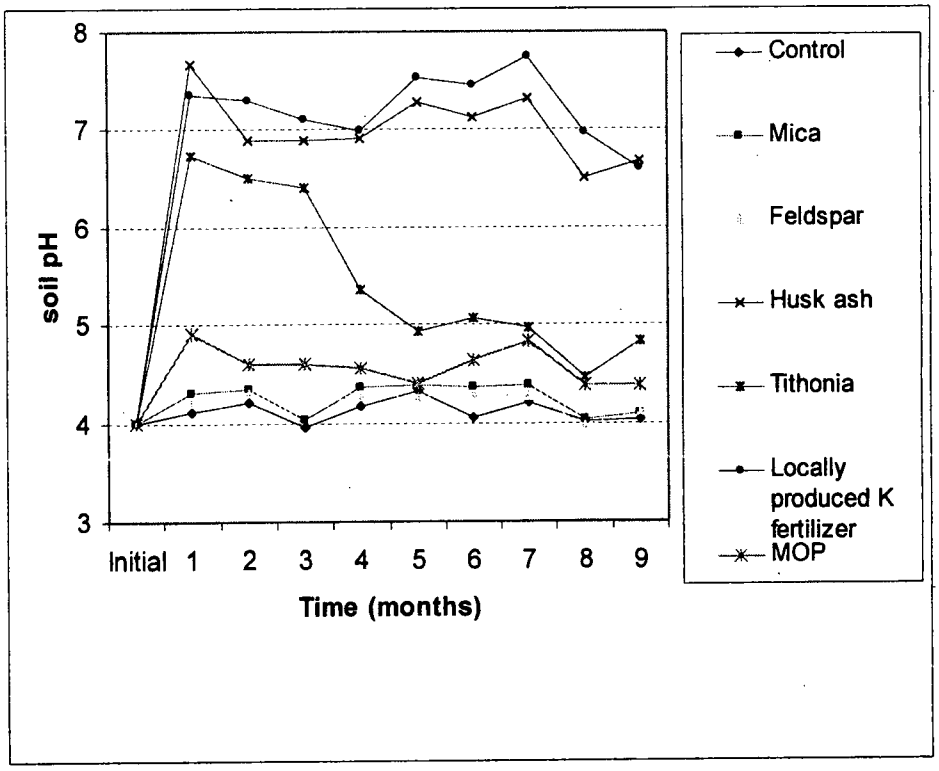

Fig 1: ***Soil pH in different treatments (Level 1)***

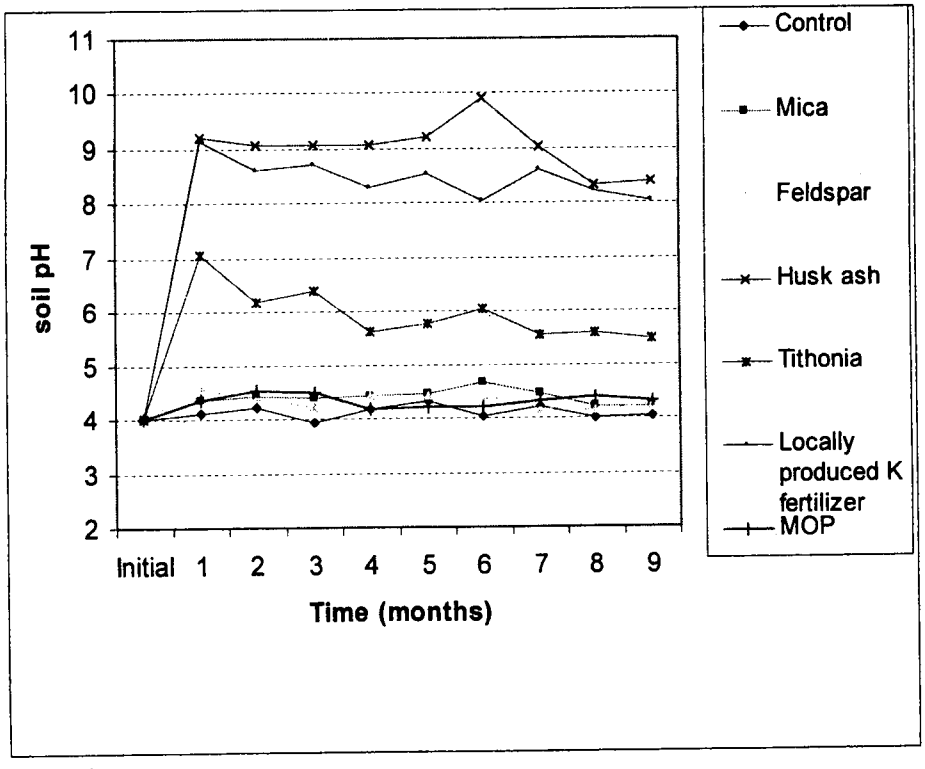

Fig 2: ***Soil pH in different treatments (Level 2)***

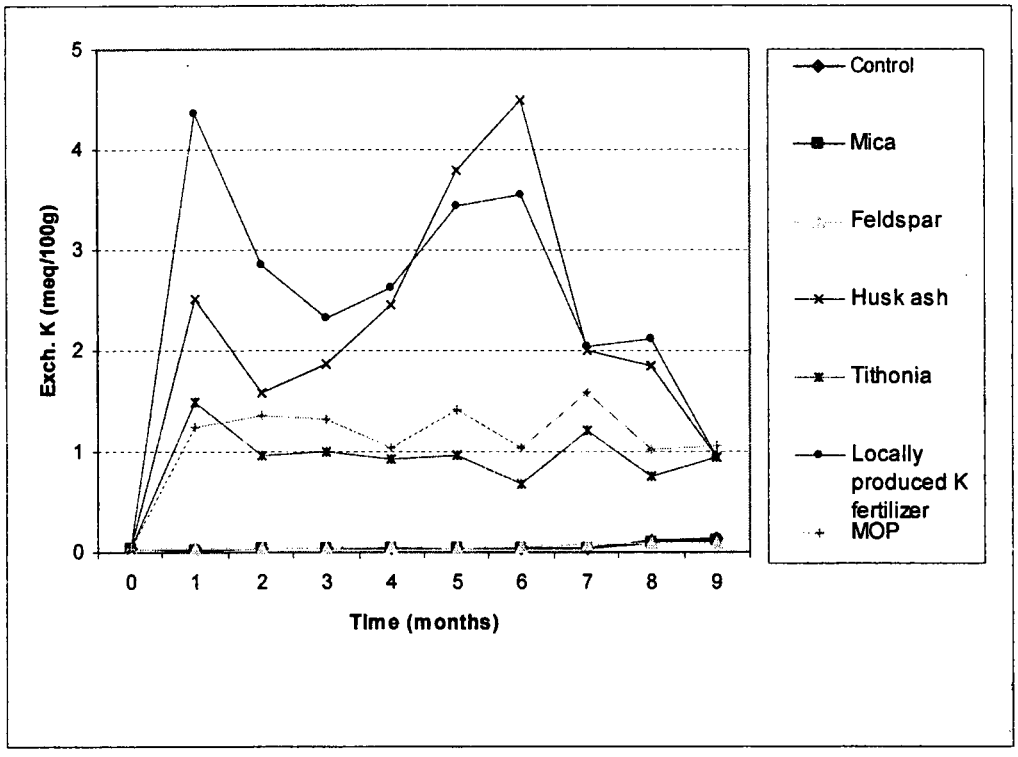

Fig 3: ***Soil exchangeable K in different treatments (Level 1)***

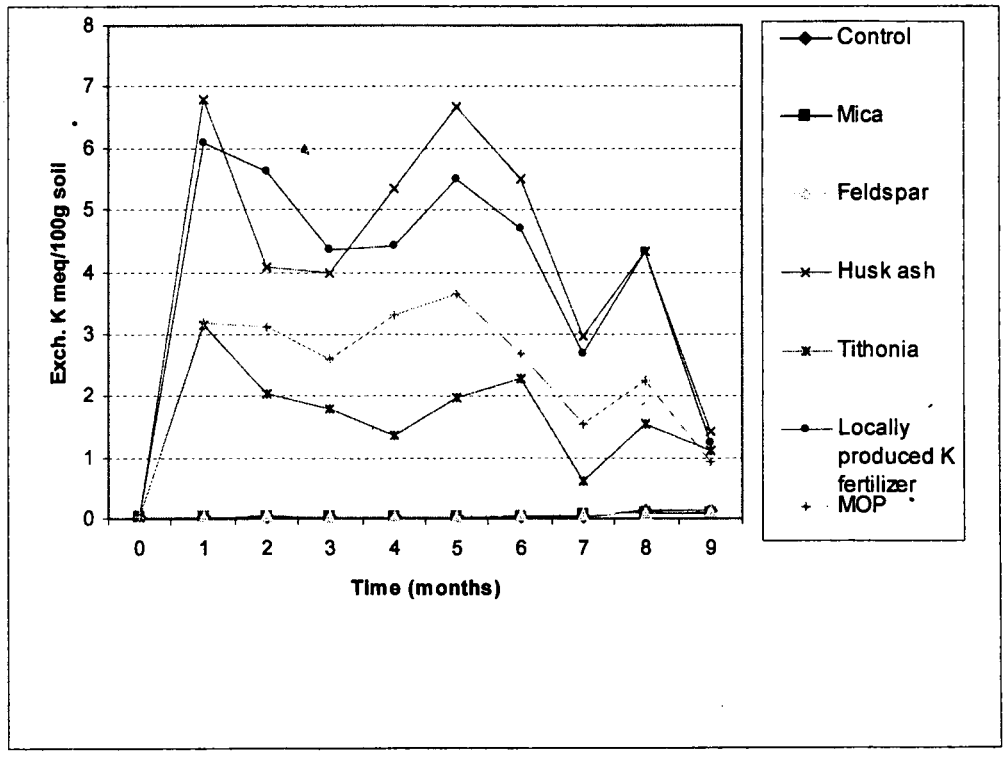

Fig 4: ***Soil exchangeable K in different treatments (Level 2)***

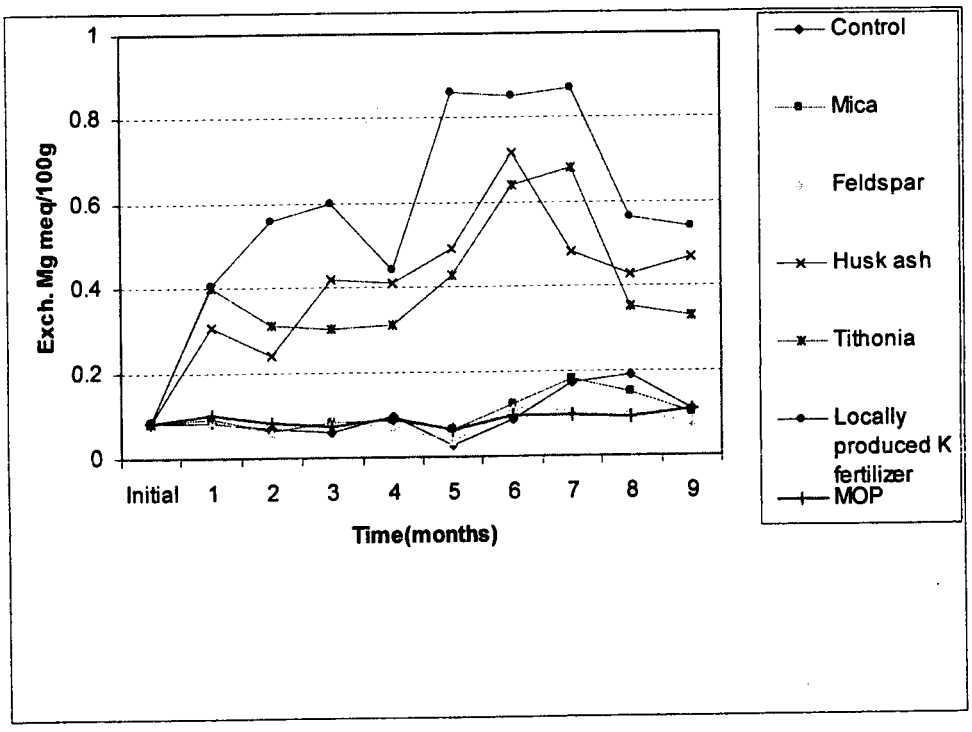

Fig 5: ***Soil exchangeable Mg in different treatments (Level 1)***

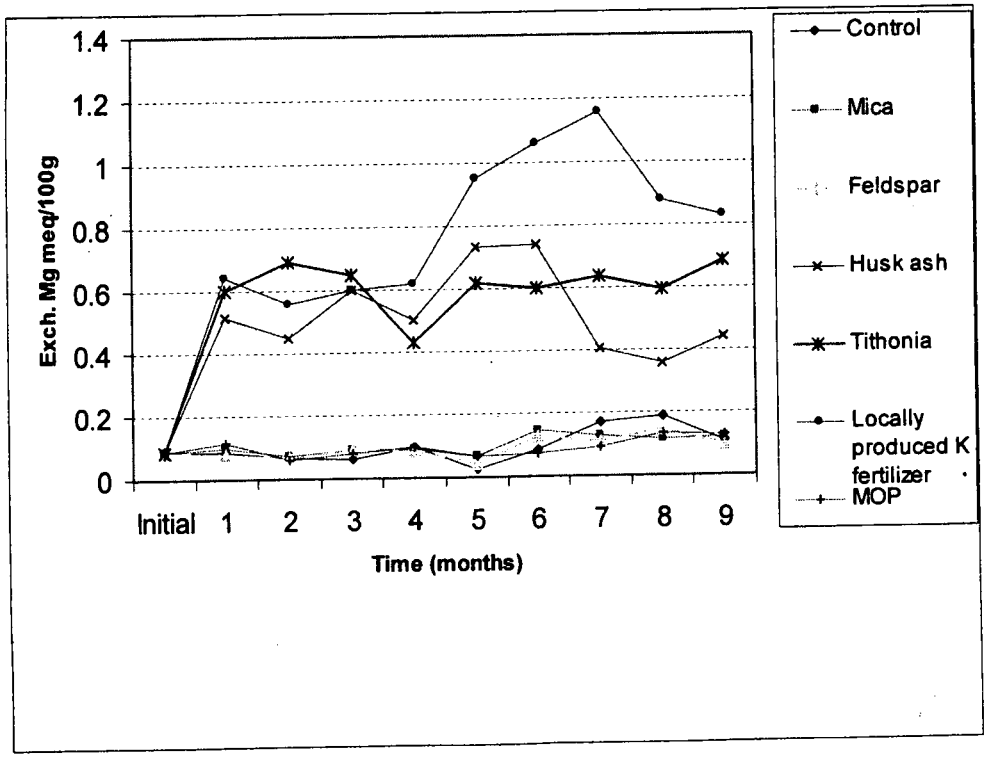

Fig 6: ***Soil exchangeable Mg in different treatments (Level 2)***

Experiment 10.0.2: Evaluating the effect of fertigation on coconut (2004)

The experiment was established in 2004 at Ratmalagara Estate (IL_1). It was located in a shallow sandy clay loam soil (Andigama series) falling into land suitability class S_5. This experiment was in Randomized Complete Block Design with 3 replicates and 6 palms (15 years old) per plot. Treatment combinations are given in Table 38.

Table 38: ***Treatment combinations of the experiment***

T_1	Control - no Fertilizer, No Irrigation (No Fertigation)
T_2	Fertilizer (3 kg APM + 1 kg Dolomite applied on the entire manure circle) + No Irrigation
T_3	No Fertilizer + Drip Irrigation (40 l/day)
T_4	Fertilizer (3 kg APM + 1 Dolomite - applied on the entire manure circle) + Drip Irrigation (40 l/day)
T_5	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)
T_6	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 a three year period are given in Table 39. Treatments were imposed in November 2007 and leaf samples were collected in August 2007. It is too early to examine significant yield response among the treatments. However, nut yield increase is 31% with fertigation than no fertigation. The nut yield increase (8.5%) in fertilizer (urea and muriate of potash) applied through drip irrigation system and Eppawala rock phosphate and dolomite applied at the point of drippers (T_5) compared with above fertilizer applied on entire manure circle with drip irrigation treatment (T_4). The nut yield difference showed as 24% compared with only drip irrigation (T_3) and fertigation (T_5/T_6).

Table 39: ***Nut yield production***

Treatment	Cumulative nut yield (nuts/palm) November 2004 to October 2007	Nut yield (palm/year) November 2007 to October 2008
T_1	230	68
T_2	219	80
T_3	220	72
T_4	218	82
T_5	259	89
T_6	265	90
Level of Significance	ns	ns

The leaf nutrient values given in Table 40 showed that there is no significant differences among the treatments. All the nutrients are in the sufficiency ranges except N. ($N \geq 1.9$ %, $P \geq 0.11$ %, $K \geq 1.2$ %, $Mg \geq 0.25$ %). But N has shown above critical levels in T_6. Kernel thickness of the nuts have also not shown significant differences among the treatments 4 years after treatment application.

Table 40: ***Leaf nutrient levels of the 14th leaf***

Treatment	N %	P %	K %	Mg %
T_1	1.80	0.14	1.49	0.24
T_2	1.85	0.15	1.67	0.25
T_3	1.68	0.15	1.47	0.26
T_4	1.83	0.15	1.59	0.27
T_5	1.84	0.15	1.54	0.27
T_6	1.99	0.15	1.68	0.27
Level of Significance	ns	ns	ns	ns

N A Tennakoon, L R M C Liyanage, D P Panditharatne and K R E M Fernando

PROJECT 27: STUDIES ON CHEMCIAL 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 Kuliyapitiya, Kurunegala, Boralu, Pallama, Wariyapola and Maho were sampled and analyzed for soil and leaf nutrient levels. The results were published in previous Annual Reports.

The Atlas of 1 inch topographical sheet of Dandagamuwa including mainly Kuliyapitiya and Kurunegala and other soil series was printed and it is available for references. The preparation of Atlas shown characteristics and the occurrence of soil series of Kurunegala and Gampaha topographical sheets are in progress.

The evaluation of nutrient status in other major soil series in the coconut triangle was considered and the basic plan to characterize soil properties of major soil series was made.

The number of samples needed to be taken from each soil series were marked and the main aim was to limit the number of samples which could adequately represent the soil series.

Global positioning system (GPS) is used to locate the sampling points in future and Chilaw topographic sheet is to be covered in next year using GPS.

N A Tennakoon, H M I K Herath, E M A T Banda, K P A Pathirana & K L Ranasinghe

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) - 1997

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

The annual treatment combinations are given in Table 41.

Table 41: ***Treatment combinations of the experiment***

T_1	Control (no fertilizer)
T_2	3 kg APM (Adult Palm Mixture) + 1 kg dolomite per palm
T_3	35 kg cattle manure + 1200 g MOP per palm
T_4	25 kg goat dung + 800 g MOP per palm
T_5	30 kg poultry manure + 750 g MOP per palm
T_6	30 kg Gliricidia + 750 g SP + 1500 g MOP + 1000 g dolomite per palm

Leaf samples collected at Ratmalagara Estate site on June 2008 were analyzed and results are given in Table 42. Leaf N, P, K and Mg have shown significant difference among the treatments. This difference was clearly shown between fertilized palms and control palms. Essential nutrients such as N, P, K and Mg were in the above critical level (N ≥ 1.9%, P ≥ 0.11%, K ≥ 1.2% & Mg ≥ 0.25)

Table 42: ***Leaf nutrient levels in the 14th frond***

Treatment	N %	P %	K %	Mg %
T_1	1.93	0.13	0.66	0.29
T_2	1.97	0.13	1.30	0.29
T_3	2.13	0.14	1.34	0.30
T_4	2.23	0.14	1.26	0.31
T_5	2.30	0.15	1.40	0.33
T_6	2.12	0.16	1.29	0.34
Level of significant	*	**	**	*
LSD ($p \leq 0.05$)	0.195	0.011	0.334	0.085

Thirty five percent increase in nut yield of the palms receiving poultry manure was observed compared to that of the control (no fertilizer). The yield increases due to application of inorganic fertilizer over the control (no fertilizer) was 6% (Table 43). Among other organic sources such as cattle manure, goat manure and gliricidia, the yield increase was 25%, 30% and 9% over the control (no fertilizer) respectively. Twenty seven percent yield increase 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 and goat manure were more economical and beneficial than that of inorganic fertilizer.

Table 43: ***Nut yield data at the Ratmalagara Experimental Site***

Treatment	Cumulative nut yield (nuts/palm) June 1997 to August 2007	Nut yield (palm/year) June 2007 to August 2008
T_1	556	63
T_2	673	67
T_3	735	79
T_4	715	82
T_5	794	85
T_6	660	69
Level of Significance	* in 2002/2003 & in 2005/2006	ns
LSD ($p \leq 0.05$)	20 (2002/2003) & 19 (2005/2006)	-

N A Tennakoon, S D H Bandara, W Gunasena & K J S Perera

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 of organic manure. Two sites were selected for this experiment.

Badalgama Site (2005)

The experiment (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 WL_3 Agro Ecological Region. The site falls into land suitability class S_4.

Treatments are given in Table 44.

Table 44: ***Treatments of the Badalgama site***

T_1	Control - only APM-W
T_2	Goat manure 35 kg per palm/yr
T_3	Goat manure 50 kg per palm/yr
T_4	Goat manure 75 kg per palm/yr
T_5	Goat manure 100 kg per palm/yr

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

Nut yields of the experiment are given in Table 45. It is too early to predict the differences of nut yield as well as female flower production among the treatments. i.e. 2nd year after treatment application.

Table 45: ***Nut yield of the experiment (March 2006 to December 2007)***

Treatment	Nut yield (per palm) (November 2006 to October 2007)	Nut yield (per palm) (November 2007 to October 2008)
T_1	76	68
T_2	81	72
T_3	77	98
T_4	80	106
T_5	86	102
Significance	ns	ns

Soil samples collected in June 2008 were analyzed and the results were given in Table 46. A significant soil improvement was not observed among the treatments, 1st year after treatment application.

Table 46: ***Soil analysis of the Badalgama site***

Treatment	pH (1:5 v/v)		EC (µs/cm)		N (mg/kg)		CEC (meq/100g)		OC %		C/N Ratio	
	I	II	I	II	I	II	I	II	I	II	I	II
T_1	6.38	5.52	101	52	694	482	7.05	7.71	2.02	1.51	29	32
T_2	6.40	5.63	136	76	755	612	7.36	8.68	2.08	1.66	27	26
T_3	6.45	6.00	172	92	877	592	8.05	9.18	2.21	1.70	27	27
T_4	6.58	5.95	261	79	1146	560	9.34	10.22	2.29	1.86	23	25
T_5	6.62	6.05	242	96	1380	677	9.36	11.27	2.88	1.87	21	27
Level of Significance	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
LSD ($p \leq 0.050$)	-	-	-	-	-	-	-	-	-	-	-	-

(I) Soil depth at 0 - 20 cm

(II) Soil depth at 20 - 40 cm

Madampe site (2007)

The site of Sudu soil series has been selected at Madampe this year. The site is in IL_3 Agro Ecological Region. The site falls into land suitability class S_4 (5,000 - 10,000 nuts/ha/yr).

The treatments of the site at Madampe are given in Table 47.

Table 47: ***Treatments of the Madampe site***

T_1	Control - only APM-W
T_2	Cattle manure 50 kg per palm/yr
T_3	Cattle manure 75 kg per palm/yr
T_4	Cattle manure 100 kg per palm/yr
T_5	Gliricidia 50 kg per palm/yr
T_6	Gliricidia 75 kg per palm/yr
T_7	Gliricidia 100 kg per palm/yr

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

Nut yields of the experiment are given in Table 48. It is too early to predict the differences of nut yield among the treatments i.e. 1st year after treatment application.

Table 48: ***Nut yield of the Madampe site***

Treatment	Nut yield (per palm) (November 2007 to October 2008)
T_1	25
T_2	27
T_3	28
T_4	28
T_5	30
T_6	31
T_7	29
Significance	ns

N A Tennakoon, H L A P Liyanage & F H A J R Silva

Experiment 30.1.3: Assessment of soil quality depletion in coconut lands in order to develop improvement resources (2005)

The objectives of the experiment were

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

The experiment was established at 3 locations namely Rathmalagara, Pallama and Walpita estates.

The Agro Ecological Region, land suitability classes and soil types of these locations are given in Table 49.

Table 49: ***Agro Ecological Regions, land suitability class and the soil types of the experimental sites***

Location	AER	Land Suitability Class	Soil Series
Rathmalagara	IL_1	S_2 & S_4	Wilattawa (S_2) and Andigama (S_4)
Pallama	IL_3	S_2 & S_4	Wilattawa (S_2) and Andigama (S_4)
Walpita	WL_3	S_2 & S_4	Pallama (S_2) and Boralu (S_4)

Soil samples were collected from center squares of the coconut land and adjoining forest land which consist of S_2 and S_4 land suitability classes. 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 72 soil samples were collected from coconut lands and forest lands at 3 locations.

Soil samples were analyzed for chemical, physical and biological parameters. Chemical and physical data at RE, Pallama and Walpita sites were reported in Annual Reports of 2006 and 2007.

Generally, the soil nutrient levels were depleted in coconut lands compared to the adjoining forest lands in the 3 AER (Wet, Intermediate and Dry zones) as well as two land suitability classes, S_2 and S_4.

Due to introduction of coconut after clearing forests, the nutrient recycling has not occurred properly. To get more nut yield, the continuous application of fertilizer is a must for a high demanding crop like coconut.

The 2nd part of this experiment i.e. nutrient status of well managed and poorly managed coconut lands has to be commenced in future. Due to financial constraints, the 2nd part of the experiment was not commenced this year.

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MISCELLANEOUS STUDIES

I. STUDIES ON ACCUMULATION OF CADMIUM IN COCONUT PLANTATION AFTER LONG TERM APPLICATION OF DIFFERENT PHOSPHATE SOURCES

It has been known that cadmium (Cd) is a non essential element found in the soil at high levels due to various human activities. Different phosphate sources that are used for the improvement of agricultural soil frequently contain high content of Cd compared to other inorganic fertilizer types. It has been revealed that Cd is taken up through the root system of many plant species and accumulates in plant parts such as root, shoot, fruit and grain; furthermore, it accumulates through the food chain. Consequently, Cd has a tendency to accumulate in the human body especially in kidneys and liver 32% and 14% respectively. Therefore, it is a necessity to identify the accumulation of Cd in coconut palm, edible parts and the soil after long term application of recommended different phosphate sources, as per capita consumption is around 120 nuts per year. Thus, the objective of this study was to study the accumulation of Cd in soil, leaf, kernel and nut water after seventeen years of application of different phosphate sources to the coconut palm. The above mentioned samples were taken for chemical analysis to identify the Cd accumulation in coconut plantations. It was revealed that soil of the experimental site was below the contaminated Cd level that is 0.4 - 0.5 mg/kg. The study indicated that, seventeen years of phosphorus fertilizer application has not increased the Cd level in the soil, leaf, nut water and kernel, although the Cd content of soil was very low. Furthermore, IRP treated palms has a tendency to accumulate Cd in the kernel than the ERP treated palms.

Mineral fertilizers contains heavy metals as residues. Accumulation of Fe, Cu, Zn, Mn etc. in the soil environment can be phytotoxic as well as damaging to the growth of soil organisms. If it exceeds a certain level in the edible portion, it could be toxic to humans. Therefore, one site at Mangala eliya has been used for this study. This experiment was commenced in 2000 and 4 levels of high dose and normal recommended dose have been applied. Heavy metals, Cd and Fe accumulation in the soil, leaf, kernel and nut water have been estimated. Cd accumulation of different sources are very low.

K D G Fernando, M K F Nadheesha, N A Tennakoon

II. EFFECT OF SOME COMMERCIAL BIO FERTILIZER ON THE GROWTH OF COCONUT SEEDLINGS AND ON THE ACTIVITY OF SOIL NUTRIENTS

An experiment was conducted to assess improvement of availability of soil Nitrogen and Phosphorus after application of bio fertilizer and to determine Nitrogen and Phosphorus levels in leaves after application of bio fertilizer. Bio Gold (*Azotobacter chrococcum* and *Pseudomonas fluorescens*) and Bio Phos (*Bacillus megatherium*) were used as bio fertilizer. Seedlings of Dwarf x Tall variety were taken as the planting material. Seven treatments; T_1 - Eppawala Rock Phosphate. T_2 - Eppawala Rock Phosphate and Bio Phos T_3 - Eppawala Rock Phosphate, Cattle manure and Bio Gold, T_4 - Eppawala Rock Phosphate and Cattle manure, T_5 - Eppawala Rock Phosphate, Urea and Bio Gold, T_6 - Eppawala Rock Phosphate and Bio Gold, T_7 - Eppawala Rock Phosphate and Urea were tested under net house conditions. The experiment was arranged in a complete randomized design with three replicates.

The study revealed that, treatment combination of Bio Gold and cattle manure had given significant contribution for increasing availability of amonical Nitrogen in soil than cattle manure alone. The total nitrogen form cattle manure and Bio Gold was higher than the total Nitrogen from urea at the second week. During the study period, there were no significant differences in the available Phosphorus among all the treatments.

H G W Pushpakumari, M K F Nadheesha & N A Tennakoon

3. SERVICE FUNCTIONS

Differential Fertilizer Recommendation	-	87 growers (2,590 ha)
Land suitability tests for coconut cultivation/surveys	-	37 growers
Inorganic fertilizer analysis	-	230 samples
Organic fertilizer analysis	-	303 samples
Analysis of coir pith samples	-	565 samples
Soil analysis	-	1859 samples
Leaf analysis	-	1848 samples
Water analysis	-	100 samples

4. EXTENSION ACTIVITIES

Dr. N.A. Tennakoon participated as a resource person in 6 programmes on Fertilizer for coconut, Nutrient deficiencies of coconut and Land suitability for coconut organized by Coconut Development Training Centre, Lunuwila.

Dr. N.A. Tennakoon participated as a resource person on Fertilizer for coconut held in Gampaha organized by Coconut Cultivation Board.

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.) D.M.D.I. Wijebandara, Miss. M.K. Fathima Nadheesha, Mrs. H.M.I.K. Herath and Mr. L.R.M.C. Liyanage participated as resource persons in one day training programme on fertilizer for coconut and irrigation for coconut conducted by Coconut Research Institute.

Mr. D.P. Panditharatne and Mr. K.L. Ranasinghe participated as a resource persons in one day training programme on Irrigation on coconut and Rehabilitation of coconut lands conducted by Coconut Research Institute.

5. ACKNOWLEDGEMENT

I 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

Research and management programme of the Weligama coconut leaf wilt disease was the main focus of the Division. Strategies were formulated and a programme was initiated to prevent spread of the disease to other areas and to improve the status of diseased palms in the affected areas. An extensive multi-disciplinary research project was commenced and a research laboratory was established at Kotawila, Matara to facilitate research activities. The current recommendation of treating red weevil infested palms with monocrotophos was revised and new increased dosages were recommended; 30ml for the palms with a circumference of the stem base less than 100cm and 40ml for palms with a circumference over 100cm.

The research on coconut mite continued with studies on population dynamics of the pest and its natural enemies and developing management strategies using biological and chemical methods. The pest reached peak populations during different months in different areas. Compared to 2007, there was a 4 – 99% increase in the pest population in all sites, except in Gampaha where a 27% decrease was recorded. Since 2000, the highest pest population was recorded in Kalpitiya and Madurankuliya during 2008. *N. baraki* was reported in all sites, but *N. paspalivorus* was predominantly and only reported from Gampaha. Development of a technology for field release of *N. baraki* was continued. The percentages of infested nuts and nuts that are sold at half price were lowest in the plots where 5000 predators/palm were released at bi-monthly intervals. Also, release of predatory mites to $1/4^{th}$ of an acre at the rate of 5000 mites per palm at bi-monthly intervals reduces the percentage of nuts that are sold at half price in the harvest. Mass scale releases of predatory mites in the Maduruoya Seed Garden resulted in higher predatory mite populations in released blocks compared to unreleased blocks. The pilot trial conducted to confirm the effectiveness of spraying *Hirsutella thompsonii* fungus at 3-monthly intervals to manage coconut mite did not show improvement in damage levels of treated palms. The pilot trials with application of a mixture of 20% palm/ vegetable oil and 0.05% wettable sulphur were completed. The percentage of small-sized nuts was significantly lower in treated palms, irrespective of the treatment frequency. Also, the percentage of undamaged nuts was higher in treated palms and the treatments, especially 6-monthly application were cost effective. The pilot trial to determine effectiveness of 3- and 6-monthly application of neem-based granules (Azadirachtin 1500ppm) in an irrigated field showed that the percentage of damaged immature nuts was lowest (19%) in palms treated at 3-monthly intervals, while it was 38.6% at 6-monthly intervals compared to 65.1% in the untreated control.

Pilot experiments were commenced to study the effect of releasing *Oryctes* virus-infected beetles and pheromone-baited traps in reducing black beetle damage.

It was indicated that pruning roots of a LSD-affected palm at 4-monthly intervals reduced the symptoms of the disorder than root pruning at other intervals and non-pruned palms. Higher root formation was observed when roots in the same area were pruned at 6 - 8 monthly intervals.

A multi-disciplinary research programme on Weligama Coconut Leaf Wilt disease (WCLWD) involving several Divisions was commenced to develop quick diagnostic methods using PCR techniques, ELISA method and staining of tissues, study disease symptomatology and epidemiology, study soil and foliar nutrient levels and assess crop loss. As a prerequisite for the research studies a disease index to categorize the diseased palms were developed. Suppression of yellowing symptom of WCLWD-affected palms was observed when 5g/ml of oxytetracycline plant formula solution was trunk injected.

A clear reduction in leaf rot disease was not observed when antagonist fungi *Aspergillus niger* and *Trichoderma viridae* spore suspensions were sprayed on to the bud region of leaf rot-affected palms. Pilot trials on effect of large scale application of recommended dose of Tebuconazole (Orius 25 EW) was commenced.

The Division provided parasitoids for the control of coconut caterpillar, pheromone to trap and manage red weevil populations and specialized advice to manage pests and diseases of coconut.

1. RESEARCH PROJECTS

PROJECT 27 CONTROL OF COCONUT MITE, *Aceria Guerreronis*

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

The study conducted to determine the annual and seasonal population fluctuation pattern of coconut mite and its predatory mites, *Neoseiulus baraki* and *N. paspalivorus* was continued in Kalpitiya, Madurankuliya, Rajanganaya, Gampaha, Kurunegala and Lunuwila. In each area, nuts were collected from 3 coconut mite infested sites in February, May, August and November which are correspondent to the dry-, wet but less intense rainfall, dry and wet with intense rainfall periods respectively. From each infested site, 10 palms were selected and 1 nut was collected from each palm in each sampling occasion. Total number of predators was determined by counting all the stages of the predators on each nut using a stereo-zoom microscope. Total number of coconut mite was estimated by the wash method.

Populations of both pest and predators fluctuated over time in all sites. Pest reached peak populations during August in Kalpitiya, Madurankuliya and Kurunegala, February in Lunuwila, May in Gampaha and November in Rajanganaya (Fig. 1). Irrespective of the season, annual mean number of coconut mites was highest in Kalpitiya (1466 mites/nut) and lowest in Gampaha (467 mites/nut). Since the year 2000, the highest coconut mite population was recorded in Kalpitiya (1466 mites/nut) and Madurankuliya (1407 mites/nut) in 2008. Compared to the year 2000 this was a 64% and 134% increase in Kalpitiya and Madurankuliya respectively.

Except in Gampaha, *N. baraki* was reported in all sites in all seasons (Table 1). But in Gampaha, *N. baraki* was reported in small numbers only in November. Instead, a similar predatory mite, *N. paspalivorus* was predominantly and only reported from Gampaha area in all seasons (Table 1). Compared to the year 2000, a 200% and a 306% increase of *N. baraki* were observed in Kalpitiya and Madurankuliya respectively in 2008. Fluctuations of *N. baraki* or *N. paspalivorus* did not follow the fluctuation pattern of the coconut mite.

The study is in progress.

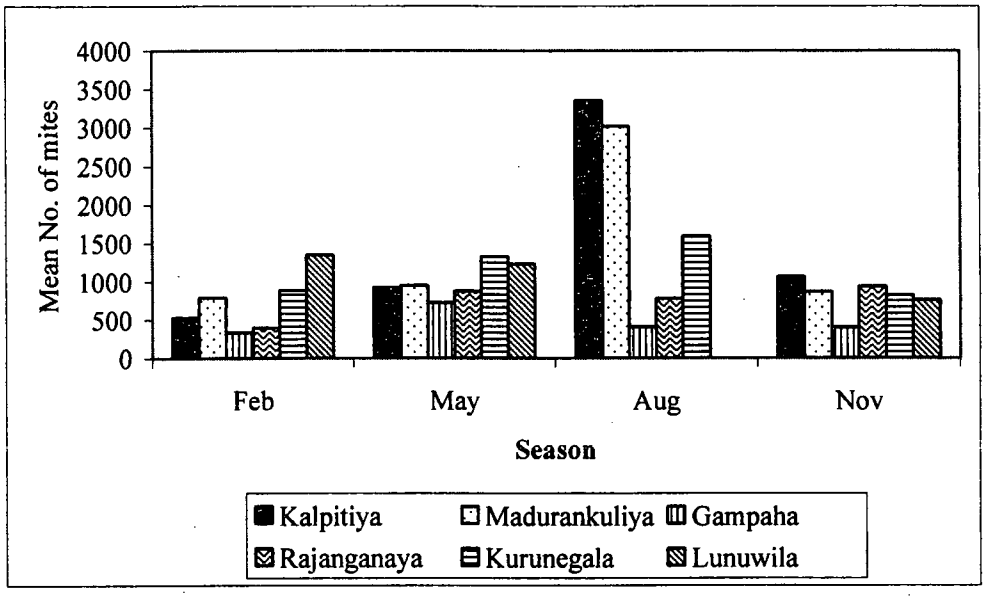

Fig. 1. Seasonal population fluctuation of coconut mite in 2008

Table1. Mean No. of N. baraki and N. paspalivorus per nut in February, June, August and November in 2008

Site	*N. baraki*				*N. paspalivorus*			
	Feb	June	Aug	Nov	Feb	June	Aug	Nov
Kapitiya	14	3	8	16	0	0	0	0
Madurankuliya	8	8	12	5	0	0	0	0
Gampaha	0	0	0	0.3	10	6	8	5
Rajanganaya	7	7	8	5	0	0	0	0
Kurunegala	12	12	8	8	0	0	0	0
Lunuwila	17	19	-	5	0	0	-	0

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

Experiment 27.70 Determination of frequency of release of *N. baraki* in the field (2006)

A study that was conducted in Weragoda estate, Pallama and the Typing estate, Mangalaeliya to determine a suitable frequency of release of *N. baraki* in the field to control the coconut mite was continued. Four 1 ac. plots (at least 6 rows away from each other) were selected in each estate. Ten coconut mite infested-palms from each plot received 5000 predatory mites/palm and the releases were repeated either at 2-month or 4-month or 6-month intervals in each plot. Control plot was maintained without releasing *N. baraki*. Release of *N. baraki* was completed in both estates and the collection of pick records was continued. The effect of release of predatory mites at different frequencies was not reflected considerably by mite census and therefore mite census was not collected in any estate in 2008. From 4 months after the 1st release, matured nuts were harvested at 2-month intervals and the total number of infested nuts, un-infested nuts, full-priced nuts, half-priced nuts and infested nuts with discontinued damage scars were counted from each palm.

In Weragoda estate, differences in the percentage of infested nuts in the harvest was not statistically significant (df = 3, F = 3.02, P = 0.06). However, a lower percentage of infested nuts were observed in treated palms than in the control palms (Table 2). The difference in the percentage of nuts that are sold at half price was statistically significant in Weragoda estate (df = 3, F = 4.4, P = 0.02). Compared to control palms, a significantly lower percentage of nuts that were sold at half price was recorded only in the palms on to which *N. baraki* was released at 2-month intervals (Table 2). Although not statistically significant the percentage of nuts that are sold at half price was lower in the palms on to which *N. baraki* was released at 4-month or 6-month intervals, compared to the control palms (Table 2). Significantly higher percentage of infested nuts with discontinued damage scars in the harvest was also recorded from the palms that received *N. baraki* at 2-month intervals (df = 3, F = 4.2, P = 0.03, Table 2).

In Typing estate, differences in the percentage of infested nuts in the harvest were statistically significant (df = 3, F = 3.3, P = 0.03). The lowest percentage of infested nuts was recorded from the palms on to which *N. baraki* was released at 2-month intervals (Table 2). There was no statistically significant difference in the percentage of nuts that were sold at half price (df = 3, F = 2.2, P = 0.11) and the percentage of infested nuts with discontinued damage scars (df = 3, F = 1.2, P = 0.31) in Typing estate. However, a lower percentage of nuts that are sold at half price and a higher percentage of infested nuts with discontinued damage scars were recorded in the palms on to which *N. baraki* was released at 2-month intervals (Table 2).

The study is being continued to evaluate the persistence of the effect of release of *N. baraki* at different frequencies.

Table 2. Effect of release of N. baraki at different frequencies on the percentage of infested nuts, half-priced nuts and infested nuts with discontinued damage scars in Weragoda and Typing estates.

Frequency	Mean percentage ±SE		
	Infested nuts*	Half-priced nuts*	Infested nuts with discontinued damage scars*
(a) Weragoda estate			
2-month	74.5±6.1ns	11.7±4.1a	39.6±6.3a
4-month	75.9±6.2ns	14.7±4.1ab	14.1±8.1ab
6-month	82.7±5.5ns	22.2±3.7ab	8.3±8.2b
Control	94.9±5.6ns	29.6±3.7b	8.0±6.4b
(b)Typing estate			
2-month	69.9±4.0a	7.1±4.5ns	30.5±5.4ns
4-month	86.8±3.3b	21.9±3.8ns	22.2±4.5ns
6-month	77.9±3.3ab	14.0±4.0ns	19.3±4.7ns
Control	87.0±3.5b	16.9±4.0ns	17.5±4.7ns

* Means followed by the same letter are not statistically significant at p=0.05, ns=not significant

Experiment 27.81 Determination of rate of release (number of palms/ac) of *N. baraki* in the field (2007)

A study that was commenced to determine the number of palms per acre to be released with *N. baraki* in the field to control the coconut mite was continued in Katana estate and Anoma estate in Mundel. In each estate four 1 ac. plots (at least 8 coconut rows away from each other) were selected. Either 16 or 11 or 6 palms (corresponding to the rates of $1/4^{th}$, $1/6^{th}$ and $1/10^{th}$ of the plot respectively) separately in each plot were released with approximately 5000 predatory mites per palm at 2-month intervals. Previous experiments revealed that the effect of release of *N. baraki* is not properly reflected by mite census. Therefore, mite census was not taken in this experiment. Instead, the total numbers of infested nuts, un-infested nuts, full-priced nuts, half-priced nuts and infested nuts with discontinued damage scars in the harvest were counted from every palm in each plot before releasing predatory mites and at monthly intervals thereafter. At the end of October, 2008 only few post release bunches were harvested in Katana estate and none of the post-release bunches had come to the harvest in the Anoma estate. Percentage infested nuts with discontinued damage scars were higher in *N. baraki* released palms than unreleased palms in Katana estate (19-25% in the released plots compared to 11% in the control plots). The experiment is in progress.

N. S. Aratchige, A. D. N. T. Kumara, K. F. G. Perera, C. Hettiarachchi, S. M. V. Jayawardena & N.G. Premasiri

Experiment 27.85 Effect of mass release of *N. baraki* (2008)

A preliminary study on the mite census revealed that the coconut mite populations are relatively very high (app. >5000 mites/nut) and the *N. baraki* numbers are very low (app. 0.6 mites/nut) at the Maduruoya Seed Garden (CRI). Furthermore, percentage nuts with predators was also low (29%) compared to the other areas (app. 62%, according to the study on population fluctuation of *N. baraki* in other areas). In addition to *N. baraki*, mites belonging to Ascidae, Tydidae and Bdellidae were also recorded. Therefore, a study was commenced at the Maduruoya Seed Garden to study the effect of mass release of *N. baraki* in an estate where *N. baraki* is available relatively in low numbers. The study was conducted as a pilot scale study. Three blocks of 5 ac. each that are about 0.5-1km distance from each other were selected. In one block, *N. baraki* was released on to 75 palms representing $1/4^{th}$ of the block and the release was repeated to the same set of palms at 3-month intervals for one year (T1). In another block, *N. baraki* was released on to 75 palms but the release was repeated to a new set of palms at 3-month intervals for one year (T2). The other block was maintained without releasing *N. baraki* (control). Effect of release of *N. baraki* is being evaluated in terms of mite census on button nuts of 5 month old and the harvest records.

After 2 consecutive releases, mean number of coconut mite was lower and the mean number of *N. baraki* was higher in the released blocks compared to the control block (Table 3). In addition, the percentage nuts with *N. baraki* was higher in the released blocks than in the control block (Table 3). Releases will be completed and data collection will be continued in the year 2009.

Table 3. Effect of mass release of N. baraki on the coconut mite and N. baraki populations and the percentage nuts with N. baraki in the Maduruoya Seed Garden (after 2 consecutive releases)

Treatment	Mean no. of coconut mite	Mean No. of *N. baraki*	Mean percentage of nuts with *N. baraki*
T1	888	19	76
T2	793	12	67
Control	1206	5	40

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Experiment 27.86 Evaluation of *N. paspalivorus* as a potential predatory mite of coconut mite (2007)

According to the study conducted to determine the population dynamics and previous studies on the distribution of *N. paspalivorus,* it is predominantly and only found in the wet areas. Furthermore, it has been observed that the coconut mite populations and its spread in the wet-zone are not as high as in the dry- and the intermediate-zones. Therefore, it is worthwhile of evaluating the effectiveness of *N. paspalivorus* as a potential predatory mite against the coconut mite. Therefore, an experiment was commenced to establish a laboratory culture of *N. paspalivorus* to study its effectiveness to control the coconut mite.

Compared to *N. baraki*, field population of *N. paspalivorus* was low. Therefore, a small laboratory culture of *N. paspalivorus* was started with about 100 field collected *N. paspalivorus* of different stages. This culture was not successfully developed apparently due to high temperature (26 ± 1^0C) in the incubator. The experiment is in progress to determine suitable rearing conditions, particularly the temperature, of *N. paspalivorus*.

N. S. Aratchige, A. D. N. T. Kumara & C. Hettiarachchi

Experiment 27.87 Niche segregation pattern of *N. baraki* and *Proctolaelaps bickleyii* and its effect on coconut mite population (2007)

Preliminary studies revealed that *P. bickleyii*, the exotic predatory mite, feeds on *N. baraki* in Sri Lanka. But in other countries they occupy the same nuts. It was hypothesized that based on the differences in their sizes, they occupy different niches on the same nut. This hypothesis was tested in a series of experiments using artificial arenas and embryo-cultured seedlings with niches of different sizes. The objectives of the study were to determine the niche segregation pattern of *P. bickleyii* and *N. baraki* on an artificial arena and in embryo-cultured seedlings and to study the effect of niche segregation of *P. bickleyii* and *N. baraki* on coconut mite populations.

Irrespective of the presence or absence of *P. bickleyii* on artificial arenas, niches of 200µm were more frequently occupied than 400µm by *N. baraki*. But this difference was statistically significant ($P<0.0001$) only in the absence of *P. bickleyii*. Niches of only 400µm were occupied by *P. bickleyii* irrespective of the presence of *N. baraki*. On embryo-cultured seedlings, irrespective of the possible threat of predation from each other, *N. baraki* and *P. bickleyii* were confined to immature (unopened) shoots and open leaf bases respectively. However, these

occupation patterns were not significantly affected by the size of the niches. Coconut mite numbers was also not significantly affected by the occupation pattern of the two species. Although *P. bickleyii* cannot reach niches <400µm, apparently, when visit niches of >200µm, *N. baraki* becomes the victims of predation by *P. bickleyii*. This might have led to a lower number of *N. baraki* in niches of 200-400µm. Presumably, even the niches of 200-400µm become enemy-free niches for coconut mites when *P. bickleyii* is present. However, more scrupulously designed experiments are necessary to elucidate this. The study is in progress.

S. V. M. Poornima (University of Peradeniya), N. S. Aratchige & N. I. Suwandarathne

Experiment 27.82 Pilot study to confirm the effectiveness of application of *H. thompsonii* at 3-monthly intervals (2007)

The pilot trial conducted to confirm the efficacy of 3-monthly application of *H. thompsonii* at Ududaddawa was completed. The study was conducted in 2 plots, each consisting of 80 coconut mite infested palms. In one plot, the palms were sprayed with *H. thompsonii* at 3-monthly intervals for one year and the other plot was kept as untreated control. After 9 months of spraying, the damage levels on harvested nuts were recorded up to one year. The results did not show a significant reduction in damage levels on harvested nuts, although percentages of damaged nuts were higher and damaged–normal sized nuts were less in the treated palms than in the untreated ones (Table 4). The results did not comply with results of the previous experiment in which the damage levels were significantly low in certain categories of damaged nuts (in Annual Report 2007) suggesting that efficacy of *H. thompsonii* is not consistent in field conditions.

Table 4. Percentage of nuts with no mite damage, damaged-normal size, damaged-small size and damaged-deformed in treated and untreated palms.

Treatment	Undamaged	damaged-normal size	damaged-small size	damaged-deformed
Treated	27.7	57.6	10.2	3.8
Untreated	23.3	66.4	7.5	0.2

L.C.P. Fernando & P. Manoj

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

The pilot trial to confirm the effectiveness of spraying a mixture of palm oil and sulphur in the management of coconut mite by quantifying the reduction in damage on developing and harvested nuts was completed. At Nikadalupotha and Nattandiya, each of 30 palms was treated at 3-monthly and 6-monthly intervals, while the blocks at Hettipola and Kobeigane were treated at 6-monthly intervals.

The results clearly demonstrated that the treatments had a very high level of damage reduction on harvested nuts. In all estates, the percentage of damaged-small size nuts were significantly low in treated palms than in the untreated palms and irrespective of the frequency of application

(Table 5). Also, the percentages of undamaged nuts were significantly higher in treated palms in all estates, except at Kobeigane. Cost benefit analysis showed that the treatments were cost effective and 6-monthly application was cost effective than 3-monthly application (Table 5). The cost per treatment per acre was estimated at Rs. 2952/- while the selling price of an undamaged and damaged-normal size nuts considered at Rs. 17/-, damaged-small size nuts at Rs. 8.50 and husk value of undamaged nuts and damaged nuts were Rs. 1/- and 0.50 respectively.

Table 5. Percentages of undamaged, damaged-normal size, damaged-small size and damaged-deformed nuts in the harvest in treated and untreated palms and cost benefit ratio of each treatment at different intervals of treatment.

Estate/ frequency	Undamaged	Damaged-normal size	Damaged-small size	Damaged-deformed	Cost benefit ratio
Nikadalupotha					
3-monthly	42.52A	54.08	1.71A	0.81	1.75
6-monthly	35.27A	60.92	2.21A	1.15	3.69
Control	20.18B	64.27	11.76B	2.81	
Prob.	P<0.05	P>0.05	P<0.001		
Dunkannawa					
3-monthly	51.9A	45.1	0.08A	1.03	0.56
6-monthly	36.3B	61	1.4A	1.22	4.15
Control	29.8B	56.3	9.9B	3.99	
Prob.	P<0.01	P>0.05	P<0.001		
Hettipola					
6-monthly	49.6A	44.2A	4.2A	1.31	2.57
Control	28.1B	50.9B	15.8B	3.45	
Prob.	P<0.01	P<0.05	P<0.01		
Kobeigane					
6-monthly	40.8	53.6	4.1A	1.1	1.96
Control	30.3	53.1	12.2B	3.19	
Prob.	P>0.05	P>0.05	P<0.05		

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

Experiment 27.84 Determination of frequency of application of palm oil and sulphur mixture (2007)

The study commenced at FNF estate, Madurankuliya and Isolated Seed Garden, Ambekelle to determine the frequency of application of palm oil and sulphur mixture continued. In each estate 3 application frequencies; 2 (March and August), 3 (March, June and August) and 4 (March, June, August and January) times a year are being tested. For each treatment at FNF estate, 27 coconut mite infested palms in 3 blocks of nine palms were selected. Similarly at ISG, 30 palms were selected in 3 blocks. A similar number of palms were used for the untreated control. Collection of damage assessment data on marked palms, at every 3 months was completed. Data collection on damage levels on nuts at harvest was commenced at both estates.

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

Experiment 26.76 Evaluation of the efficacy of Neem granule against coconut mite (2007)

In a previous study, it was suggested that applying 120g of Neem based granules (Azadirachtin 1500ppm) effectively reduces the damage nuts on treated palms. Therefore, a pilot trial was commenced to confirm this finding and determine the suitable frequency of application. Three blocks of half-acre (app. 34 palms) were selected in an irrigated coconut plantation in Mundel and 120g of Neem based granules were applied at 3- and 6- monthly intervals in 2 blocks while the other block was kept as untreated control. The percentage damaged nuts in newly developing bunches and pick records were taken from 15 randomly selected palms from each block. The experiment was completed.

The results indicated that the mean percentage of damaged nuts on newly developing bunches in 3-monthly treated palms was significantly lower ($F = 4.625$, $p = 0.047$) than the 6-monthly treated palms and untreated palms. Also, at every sampling time the mean percentage of damaged nuts on developing bunches were lower in treated palms than the control (Fig. 2).

The results of covariate analysis showed that the mean percentage of damaged nuts at harvest in treated palms were not significantly different to that of control palms ($F = 3.05$, $p = 0.07$). However, those nuts in 3-monthly treated palms were lower than the untreated palms and 6-monthly treated palms in all picks (Fig. 3).

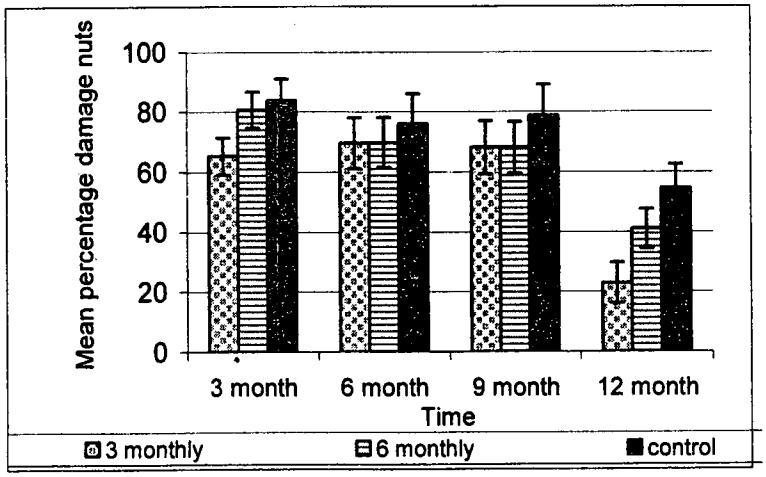

Fig. 2. Adjusted mean percentage damaged nuts (±SE) on newly developing bunches on palms treated with Neem granule (120g) at different frequencies.

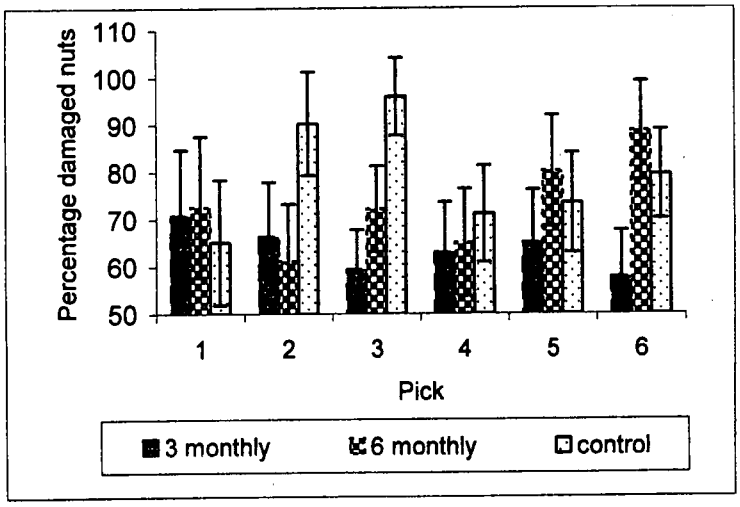

Fig. 3. Adjusted mean percentage of damaged nuts (±SE) at harvest in different treatments

The percentage of full-priced nuts were not significantly different among treatments and untreated control palms (F = 2.57, p = 0.098). However the percentage of full-priced nuts at 3-monthly treated palms was higher than the control and 6-monthly treated palms in all picks after treatment (Fig. 4). The percentage of half-priced nuts at harvest was significantly lower (F = 4.09, p = 0.03) in 3-monthly treated palms compared to 6-monthly treated and untreated control palms (Fig. 5).

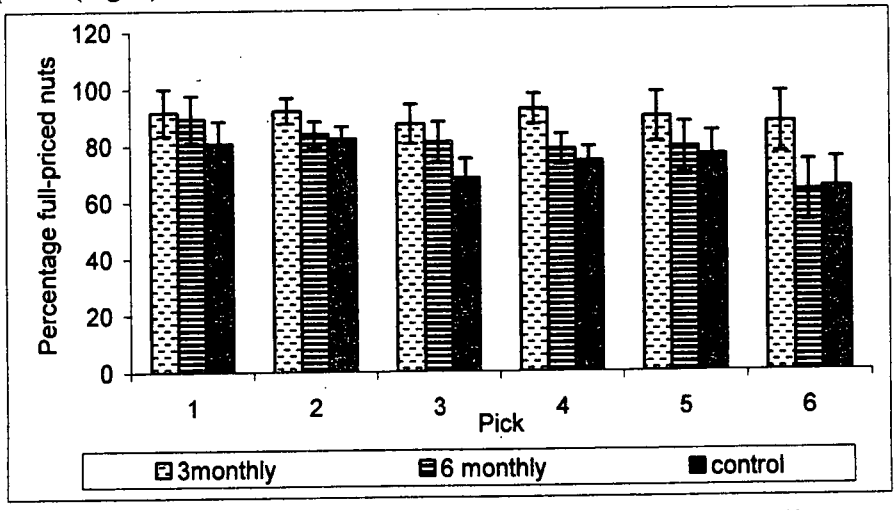

Fig. 4. Adjusted mean percentage (±SE) of full-priced nuts in different treatments

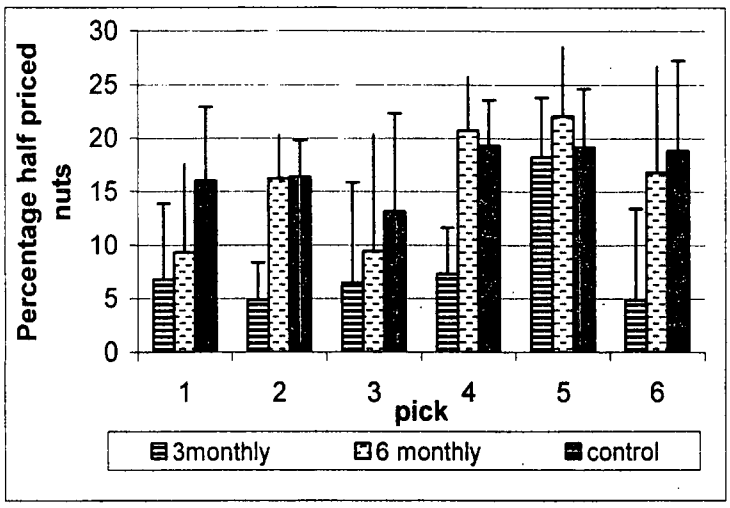

Fig. 5. ***Adjusted mean percentage (±SE) half-priced nuts in different treatments***

The results indicated that repeated application of 120g of Neem granules at 3- monthly intervals effectively reduces the coconut mite damage on developing nuts and half-price nuts at harvest in irrigated fields. Further, it increases the percentage of full-priced nuts in the harvest. Since, the treatment is effective in irrigated fields application in un-irrigated soils will not be useful. Hence, this could be only recommended for irrigated lands.

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

PROJECT 26: MANAGEMENT OF BLACK BEETLE USING PHEROMONE AND ORYCTES VIRUS (2008)

Experiment 26.1 Determine the effect of releasing *Oryctes* virus (Orv) infected beetles in reducing damage (2008)

A study was commenced to determine the effect of releasing Orv infected beetles in reducing black beetle damage in a 50-acre area consisting three adjoining villages in Kudawewa CDO range. Three hundred palms were marked to assess the black beetle damage. Before releasing Orv infected beetles, the natural incidence of the virus in the wild beetle population was assessed by trapping beetles using pheromone-baited traps, dissecting and staining their guts. The natural incidence was 14% prior to release of virus infected beetles. The total number of leaves, number of damaged leaves, number of cuts on the first 4 immature leaves and damage on the bud leaf was recorded prior to the treatment. Also, the bud leaf of the each palm was marked for ease of subsequent assessments. Orv infected beetles were released once at the rate of 300 beetles. Post-treatment damage assessments were taken at 4-monthly intervals and at each assessment damage on the fresh bud leaf and leaves that emerged after the previously marked frond was assessed. The study is in progress.

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were baited with synthetic aggregation pheromone namely, ethyl 4-methyloctonate. Fifty traps were installed at the rate of one trap per acre. Two hundred and fifty palms were marked for the damage assessments to be made at three-monthly intervals. Total number of leaves, number of damaged leaves, number of cuts on the first 4 immature leaves and damage on the bud leaf were taken as the pre-treatment damage assessments, while the bud leaf of each palm was marked for subsequent assessments. Number of beetles trapped in the traps was collected at ten day intervals. After five months of pheromone installation, total of 2979 beetles were caught. This study is in progress.

L. C. P. Fernando, N. I. Suwandhrathne, K. F. G. Perera & K.W.M. Gayan

Experiment 26.3 Comparison of the virulence of local and Philippine (DRC) isolates of *Metarhizium anisopliae* against *O. rhinoceros* larvae (2007)

In the Philippines, the DRC isolate of *M. anisopliae* has consistently shown relatively high (100%) infectivity rate of *O. rhinoceros* larvae compared to other isolates found in there. Therefore, it was intended to compare the DRC isolate with the local isolate (Sri Lankan) and to evaluate the possibility of introducing DRC isolate in the effective management of black beetle in Sri Lanka.

Field collected third-instar larvae of black beetle were infected with spore suspensions of 10^6 spores/ml of the two isolates. The inoculated larvae were then transferred into clean clay pots filled with sterilized, moisten cow dung separately and examined on the 7th, 10th, 13th and 17th day after treatment. The number of dead larvae due to *M. anisopliae* infection and other causes were counted separately. The data was averaged into cumulative values and LT_{50} values were estimated.

Black beetle larvae were killed by both local and DRC isolates of *M. anisopliae*. However, the percentage mortality of larvae was not significantly different between the two isolates. At the final observation, local isolate showed 76.14% cumulative mortality compared to 60.23% of the DRC isolate. The estimated lethal time to kill 50% of the inoculated larvae of the population (LT_{50}) for local isolate was 13 days, whereas it was 14 days for DRC isolate (Fig. 6). The results indicated that the local isolate was more virulent than the DRC isolate as shown by higher percentage mortality and the lower LT_{50}.

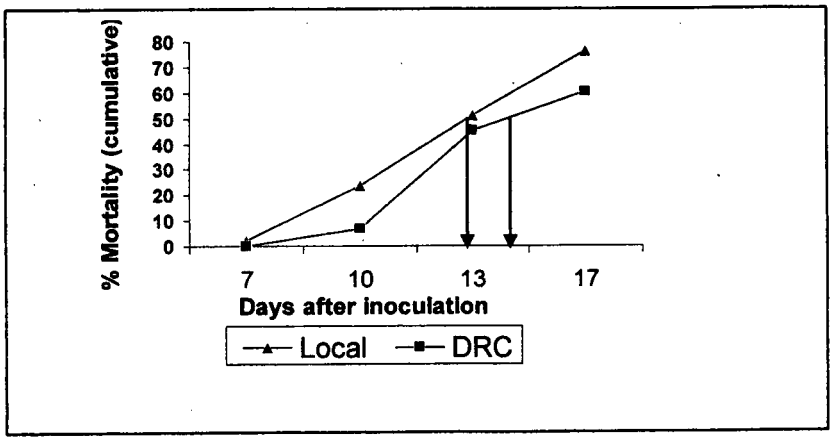


Fig. 6. Estimation of LT_{50} of two isolates of M. anisopliae

Experiment 26.4 Effect of temperature on the growth of local and DRC isolates of *M. anisopliae* in the laboratory (2007)

Effect of temperature on the growth and spore production of local and DRC isolates of *M. anisopliae* were studied in the laboratory. The culture plates were incubated at three different temperatures; 25±0.5^{0}C, 27.5±0.5^{0}C and 30±0.5^{0}C.The radial growth from the centre to the edge of the colony was measured at four-day intervals until the colony reaches the edge of the plate. In the local isolate the lowest growth of the mycelium (mean length) was at 25^{0}C and highest at 27.5^{0}C. The growth was lower at 30^{0}C and 32.5^{0}C than at 27.5^{0}C indicating that temperatures above 27.5^{0}C are detrimental to the growth of the local isolate. The DRC isolate also showed a similar trend to that of the local isolate. Growth of the mycelium was higher at 30^{0}C and 27.5^{0}C in the DRC isolate.

Spore count was done by cutting a culture plug 2cm far from the center of the culture plate using a sterile cork borer. Then the plug was shaken in 10ml distilled water and spores were counted using a haemocytometer. Spore counts were continued at four- day intervals for one month period. The local and DRC isolates were significantly different in number of spores produced at different temperature regimes tested. However, both isolates showed the same trend in spore production with respect to the temperature. At all time intervals the mean number of spores produced by the local isolate was significantly higher (Table 6). Also, at all the three temperatures spore production increased with time. Among the three different temperatures tested in the two isolates, the highest spore production was observed at 25^{0}C. At this temperature, the number of spores produced was highest in the local isolate compared to the DRC isolate. The average spore production of local isolate was 103.1× 10^4 spores/ml at 25^{0}C after 24 days of inoculation.

Table 6. Mean spore production of local and DRC isolates of M. anisopliae over time

Time -(Days)	Means spore counts		Significant Level
	Local	DRC	
4	0	0	0
8	304000	181583	0.0068
12	439333	204500	0.0057
16	646666	202250	<0.0001
20	806333	391750	0.0002
24	878000	542083	0.0129

Based on the facts that the local isolate performed better than DRC isolate and it is already established in the country it is recommended to use local isolate to manage black beetle in Sri Lanka.

W.G.R. Subathma (University of Peradeniya), N. I. Suwandhrathne& L. C. P. Fernando

PROJECT 27 DEVELOPMENT OF BIOLOGICAL METHODS TO MANAGE PLESISPA BEETLE (*Plesispa rechie)* (2007)

Experiment 27.1 Survey for natural enemies of Plesispa beetle and development of a population assessment method (2007)

A study was conducted to search for natural enemies of Plesispa beetle and to develop a population assessment method. Two sets of thirty seedlings established at Rathmalagara and Makadura estates were examined by destructive and non-destructive methods. The number of eggs, larva, pupa and adults of Plesispa beetle were recorded (Table 7). Both adults and eggs were present on leaf laminar of opened and folded fronds, whereas larval and pupal stages were found on the folded leaves. About 40% damage incidence was found in the field. Both methods recorded similar number of different stages of the beetle indicating that non destructive method could be used in future assessments. No natural enemies, except few ear wigs, which is a general predator was revealed. Continuous application of pesticide may hinder the development of natural enemies.

Table 7. Numbers of different stages of Plesispa reichei

Method	Eggs	Larva	Pupa	Adult beetles
Destructive	16	17	6	14
Non-destructive	13	15	5	15
Mean (%)	48.33	53.33	18.33	48.33

N. I. Suwandhrathne & K.W.M Gayan

PROJECT 28 STUDIES ON THE ASSOCIATION OF PARASITIC NEMATODES AND FUNGI WITH LEAF SCORCH DECLINE OF COCONUT (2001)

Experiment 28.5 The study on the effect of root pruning in remission of LSD symptoms (2006)

The study initiated to assess the effect of root pruning on remission of symptoms was continued at Bandirippuwa, Rathmalagara and Pottukulama estates. In each estate, roots of 1/3 of the manure circle (up to a depth of 9") and ½ of the circle was pruned at 2-, 4- and 6-monthly intervals. Each treatment consisted of 15 palms. Fifteen palms were kept as the control. The total number of leaves and the number of newly affected fronds of all palms were recorded at 4 monthly intervals.

The observations recorded so far revealed that pruning of roots reduces the production of scorched leaves compared to the untreated control (Tables 8 - 10). This effect was more pronounced in the palms pruned at 4-monthly intervals, irrespective of trench size. The study is in progress.

Table 8. The mean number of newly produced roots when roots are pruned in ½ and 1/3 trenches at different 2-, 4- and 6-monthly intervals at Potthukulama Research Station, CRI.

Treatment	Mean no. of newly produced scorched leaves at different months							
	0	4	8	12	16	20	24	28
2-monthly, ½ trench	1.5	1.9	1.5	2.5	2.5	3.3	3.9	4.8
2-monthly, 1/3 trench	1.6	1.3	1.5	0.6	2.2	2.8	3.6	4.3
4-monthly, ½ trench	1.6	0.9	1.6	1.3	1.8	2.8	3.5	3.4
4-monthly, 1/3 trench	1.7	1.0	1.8	1.1	2.2	3.5	3.8	3.5
6-monthly, ½ trench	1.4	1.8	1.7	1.2	2.7	3.0	3.6	3.7
6-monthly, 1/3 trench	1.6	1.5	1.4	1.7	2.6	3.3	4.1	4.9
No trench (control)	1.6	1.7	1.7	2.7	2.5	3.5	4.7	5.5

Table 9. The mean number of newly produced roots when roots are pruned in ½ and 1/3 trenches at different 2-, 4- and 6-monthly intervals at Rathmalagara estate, CRI.

Treatment	Mean no. of newly produced scorched leaves at different months							
	0	4	8	12	16	20	24	28
2-monthly, ½ trench	1.2	1.1	2.3	2.0	2.7	2.9	3.1	3.8
2-monthly, 1/3 trench	1.5	0.4	1.9	0.8	2.9	3.3	2.9	3.5
4-monthly, ½ trench	1.1	0.6	1.4	0.6	1.1	2.0	2.3	2.0
4-monthly, 1/3 trench	1.5	1.2	1.4	0.9	1.5	1.9	2.3	2.3
6-monthly, ½ trench	1.2	0.2	1.6	0.7	2.5	2.3	2.2	2.1
6-monthly, 1/3 trench	1.2	1.1	1.5	0.8	3.1	3.2	2.9	3.3
No trench (control)	1.3	1.7	2.3	1.3	2.9	3.5	4.1	4.4

Table 10. The mean number of newly produced roots when roots are pruned in ½ and 1/3 trenches at different 2-, 4- and 6-monthly intervals at Bandirippuwa estate, CRI.

Treatment	Mean no. of newly produced scorched leaves at different months							
	0	4	8	12	16	20	24	28
2-monthly, ½ trench	1.6	2.1	1.4	1.9	1.7	3.7	3.9	3.8
2-monthly, 1/3 trench	1.7	2.2	1.4	2.1	1.7	4.5	3.9	4.6
4-monthly, ½ trench	1.6	2.6	2.3	2.1	1.4	3.2	3.8	3.6
4-monthly, 1/3 trench	1.5	2.3	2.2	2.0	1.5	2.7	3.5	3.6
6-monthly, ½ trench	1.6	2.3	3.1	1.7	1.6	3.6	3.9	3.9
6-monthly, 1/3 trench	1.7	2.3	1.4	2.0	2.0	2.3	4.1	4.8
No trench (control)	1.8	2.5	1.4	1.6	2.1	3.2	4.3	5.5

MULTI- DISCIPLINARY PROJECT B26.5 STUDIES ON WELIGAMA COCONUT LEAF WILT DISEASE (WCLWD) (2008)

The 12-member Steering Committee appointed by the Coconut Research Board recommended strategies to prevent the spread of the disease to other areas and improve the status of palms in the diseased areas.

a. To prevent spread
   i. The 80km long boundary of the diseased area was identified by a preliminary survey. It is A17 road from Galle to Akuresse, Akuresse to Kirinda-Puhulwella through Kamburupitiya, Kirinda- Puhulwella to Walasmulla, Walasmulle to Beliatte and Beliatte to Tangalle. It is recommended to maintain a 3km wide disease-free boundary zone (2km interior and 1km outside the border) around the affected area by removing all diseased palms.
   ii. The Department of Agriculture declared WCLWD and leaf rot disease as quarantine pests by gazette notification (No. 1542/7 of 12th March 2008) giving provisions to carry out actions to control and prevent spread of the diseases. Accordingly, transport of coconut and other palm species and their live parts (excluding de-husked coconuts and areca nuts) out of the affected areas was prohibited.
b. To improve vigor of palms and economy of growers
   i. The coconut growers are encouraged to carry out recommended agronomic practices to improve vigor of palms.
   ii. Encourage to grow alternative crops to improve their economic status (including animal husbandry).

Several publications and media materials were produced and awareness programmes were conducted by the CRI and CCB to make the coconut growers and general public aware of the disease and recommended management strategies. Management of the disease free boundary and regular inspection of the boundary area is carried out by the CCB.

a. Publications and mass media programmes:

   i. A colour poster with pictures showing symptoms of WCLWD and leaf rot diseases and requesting coconut growers to report if any suspected palms are found in their land – 5000 copies.
   ii. A booklet titled "Recommendations for the management of Weligama Coconut Leaf Wilt Disease and Coconut Leaf Rot Disease" giving details of recommended methods and procedures to manage the diseases – 17,000 copies in Sinhala and 1000 copies in English.
   iii. A handout giving details on both diseases – 10,000 copies.
   iv. A poster showing the affected areas and the disease boundary and giving information on prohibited items for transport out of affected areas – 10,000 copies.
   v. Display boards (6'x4') giving warning messages about the diseases to be displayed at police check points – 15 boards.
   vi. Two hoardings of 8'x5' size were erected at Galle (Galle-Akuressa junction) and Tangalle town informing the public about the danger of the disease and not to transport fresh palm material out of the boundary area.
   vii. Half-page coloured newspaper advertisement describing the disease published in Daily Lankadeepa, Dinamina, Divaina and Sunday Lankadeepa.
   viii. Telecasted a 30s TV spots for a period of one month in ITN channel.

ix. Broadcasted radio spots by SLBC for a period of one month
x. Participated in a live TV discussion in ITN.

b. Training and awareness programmes conducted jointly by CRI and CCB:

i. Presentations on the diseases to District and Divisional Secretaries, Provincial Director of Agriculture, Assistant Commissioners of Agrarian Services, KRUPANISA Officers, Agriculture Instructors, Grama Niladharis and Samurdhi Officers of Matara, Hambantota and Galle districts.
ii. DIG/ SP of Police of Galle, Matara and Hambantota districts were briefed about the disease and the danger of its spread and sought their assistance to stop transport of prohibited plant materials.

An extensive multi-disciplinary research programme was commenced to address all aspects related to the disease. A research laboratory was established at Kotawila, Matara and the Senior Plant Pathologist of CRI was stationed. Four Research Assistants were recruited to assist in the project and three of them were stationed at Matara.

SUB PROJECT B26.5.1 DEVELOPMENT OF READY DIAGNOSTIC CRITERIA TO IDENTIFY WCLWD-AFFECTED PALMS (2008)

Experiment B26.5.1.1 Studies on detection of phytoplasma pathogen in WCLWD affected palms (2008)

WCLWD, which showed similar symptoms to Kerala (Root) Wilt disease in India was tested for the presence of phytoplasma using Polymerase Chain Reaction (PCR) technique during the year. DNA was extracted from trunk shavings, young leaves and roots from 10 healthy and 10 diseased palms using CTAB DNA extraction procedure. Nested PCR approach with primer combinations R16F2n-R16R2/rU3/fU5 and R16mF2-R16mR1/rU3-fU5 were used for the PCR amplification. DNA extracted from leaf samples of two diseased palms produced positive PCR products with both primer combinations. PCR products were run in a low melting Agorose gel and were purified from the gel using Wizard SV Gel and PCR Clean-up system (Promega, USA). Purified samples were sent to Macrogen Inc., South Korea for sequencing and sequence homology of both sequences was tested by blasting in the NCBI internet sequence database. Blast results confirmed WCLWD is associated with a phytoplasma in the Bermuda grass white leaf group (16SrXIV), species *Ca.* Phytoplasma cynodontis'. WCLWD phytoplasma is found to be highly (98%) similar to Sugarcane white leaf and grassy shoot phytoplasmas. This is the first report of a phytoplasma disease in coconut in Sri Lanka.

L. Perera, M. K. Meegahakumbura, W. B. S. Fernando (Genetics and Plant Breeding Division) & H.T.R. Wijesekara (Crop Protection Division)

Experiment B26.5.1.2 Preliminary study on using Diene's stain to detect WCLWD phytoplasma infected coconut tissues (2008)

Since, currently used methods (e.g. PCR) for detection of phytoplasma in WCLWD affected palms are expensive and time consuming development of a quick and reliable technique was required. A preliminary study was conducted using thin sections from several tissues; tender

roots, tender inflorescence stalks and tender ekel of the affected, apparently healthy palms from the affected area and healthy palms from the disease-free area to identify the most suitable tissue for proper staining. Tissue sections were stained with Diene's stain and examined under a light microscope.

All tissues were successfully stained by the Diene's stain. However, it was found that thin sections (of single-cell layer) can easily be obtained from the tender inflorescence stalks and tender roots. However, the high tannin content in tender root sections obstructed the differentiation of stained and unstained cells. Therefore tender inflorescence stalks of -2 stage (i.e. 2 months younger than the recently opened inflorescence) was selected as the most suitable plant part to use in further studies.

N. I. Suwandarathne, A. D. N. T. Kumara & N. S. Aratchige (Crop Protection Division)

Experiment B26.5.1.3 Development of an ELISA procedure to detect WCLWD phytoplasma (2008)

Studies were commenced to develop an Enzyme Linked Immunosorbant Assay (ELISA) method to detect WCLWD affected palms. Polyclonal antiserum was produced and a diagnostic kit was developed. Using the diagnostic kit, 100 samples of spear sheath leaves of coconut collected from disease affected areas and healthy areas, provided by Coconut Research Institute were tested. Out of the tissues of severely-affected, moderately-affected, mild-affected palms 80%, 70% and 60% samples were positive respectively, whereas from healthy tissues also 77% were positive. Furthermore, sensitivity of detection will be carried out for better separation of diseases and healthy.

E.M. Dassanayaka, C. Ranasinghe, D. Gunasekera & B.M. Rathnabarathi (Virus Indexing Centre, Department of Agriculture)

Experiment B26.5.1.4 Detection of phytoplasma and other cellular changes of WCLWD tissues using transmission electron microscopic (nano imaging) studies (2008)

The objective of this study was to determine the presence of sub-cellular pathogens in WCLWD and leaf rot affected palms by Transmission Electron Microscopy (TEM). Samples of ekel (mid rib) and tender flower stalk were collected from apparently healthy, WCLWD and leaf rot affected palms from two sites namely Nugagaha watta and Rubber watta at Kotawila area in Weligama. Sampling was conducted on three palms from each category. Samples were fixed immediately after sampling in 0.1 M phosphate buffer (pH = 7) with 3% Glutaraldehyde and 3% Formaldehyde and stored under refrigerated conditions (approximately 4°C) for more than 48 hours prior to dispatching to the Iowa State University (ISU), USA where the final nano-imaging process was conducted. The study is in progress.

A. Nainanayake, H. C. Mendis (Plant Physiology Division) & T Weerakkody (WCLWD research project)

SUB PROJECT B26.5.2 STUDIES ON DISEASE SYMPTOMATOLOGY OF WCLWD AFFECTED PALMS (2008)

Experiment B26.5.2.1 Development of a disease index to categorize WCLWD affected palms (2008)

It has been required to develop an index to categorize WCLWD affected palms into different disease severity groups, which could be used in all experiments related to WCLWD.
Simple random sampling of 260 diseased adult coconut palms in different affected areas was used. The occurrence of foliar symptoms; flaccidity (F), yellowing (Y) and marginal necrosis (N) were recorded in each coconut frond of each palm as percentage values along five spirals of the canopy. At the same time visual classification of palms in to three severity classes (mild, moderate & severe). According to the distribution of disease symptoms within selected sample percentage contribution by each symptom was calculated. The highest contribution to the disease was recorded from flaccidity as it contributed by 50% in expressing the WLWD (Table 11). Scores were also given to each symptom, considering the distribution of respective symptom in each frond. The allocation of scores to each symptom is given in Table 12.

Table 11. Partitioning of the percentage of diseased palms under three symptoms, singly and in combination.

Source	Flaccidity	Yellowing	Necrosis
Single Contributions	31.3	0.5	0
F+Y	31.4	31.4	
F+N	0	-	-
Y+N		0.4	0.4
F+Y+N	36.1	36.1	36.1
Total	50.1	31.0	18.8

The weights were calculated according to number of score classes and percentage contribution to express the disease.
For disease palms, a = 50/5 = 10; B = 30/2 = 15; c = 20/2 = 10
Therefore, the disease index for adult coconut palms can be expressed as

$$I = \frac{\text{Sum } (10F + 15Y = 10N)}{L}$$

Where, I - disease index
L - Total number of fronds in a spiral

Table 12. Scores given for flaccidity (F), yellowing (Y) and necrosis (N)

Score	F	Y	N
1	0-20	0-20	0-20
2	20-40	>20	>20
3	40-60		
4	60-80		
5	>80		

This index quantifies the intensity of disease from 0 to 100, where 0 represents the total absence of all visual symptoms while 100 means acute stage of the disease. If I is below 40 the palm is classified as mild; between 40 - 65 as moderate and above 65 as severe stage. Any one spiral of the canopy can be considered to calculate the disease intensity, as expression of disease in the five spirals was not significantly different.

P. Waidyarathne (Biometry Division), A. Nainanayake (Plant Physiology Division), H. T. R. Wijesekara, A. D. N. T. Kumara, R. de Silva (Crop Protection Division), W. G. R. Subathma (WCLWD research project), I. Herath (Soil and Plant Nutrition Division)

Experiment B26.5.2.2 Studies on disease symptomatology of WCLWD (2008)

The main objective of this experiment is to evaluate and quantify the impact of WCLWD on the performance of the palm and its productivity based on physiological parameters, yield and nut characteristics. It is further expected to develop a possible early diagnostic method based on physiological parameters prior to the expression of morphological symptoms. Four experimental sites were selected in this regard covering regularly fertilized (2 sites) and unfertilized estates (2 sites) from Weligama area. Selection and categorization of affected palms are scheduled to conduct based on the disease severity index. Accordingly, five different categories i.e. apparently healthy (control) with no symptoms mentioned above, mild, moderate and severe categories with a mixture of all above symptoms in advancing intensities and leaf rot affected palms are to be selected for the studies on symptomatology. Six palms will be included from each category from each site. A further set of similar palms is to be identified only from unfertilized estates for the application of inorganic fertilizers by Soils and Plant Nutrition Division to investigate the possible improvement or recovery of disease severity. Evaluation of the impact of disease will be monitored using following parameters.

Morphological; total number of fronds, disease severity Index, estimation of total canopy area (m^2), dead / functioning root ratio and formation of new roots.

Anatomical; stomatal density, stomatal index, percentage opening of stomata at different times of the day (@ 10 am and 2 pm), epidermal cell length, width and area, observation of T.S of leaf and root under microscopy.

Physiological; rate of photosynthesis and transpiration, stomatal conductance and Leaf water potential.

Reproductive; length of the inflorescence (cm), circumference of the inflorescence at the widest position (cm), number of female flowers per inflorescence, pollen sterility and germination, nut setting and final yield, nut weight, husked nut weight, split nut weight, kernel fresh weight, copra weight, kernel thickness, copra quality & oil content, shell characters, husk characters and fibre quality.

The study is n progress.

A. Nainanayake (Plant Physiology Division), H. T. R. Wijesekara (Crop Protection Division), P. Waidyaratne (Biometry Division), I. Herath (Soils & Plant Nutrition Division), T. Weerakkody, W. G. R. Subathma & D. Hettiarachchi (WCLWD research project)

SUB PROJECT 26.5.3 STUDIES ON DISEASE EPIDEMIOLOGY OF WCLWD (2008)

Experiment 26.5.3.1 Studies on distribution, advancement and pattern of spread of Weligama leaf wilt disease (2008)

Since WLWD was reported recently, no information on symptom development time, palm-to-palm variation in symptoms, progress of symptoms within a palm, between palms, distribution pattern of WLWD and leaf rot palms, on set of leaf rot disease are available. The study was initiated to understand these parameters.

The experiment is planned to be conducted in 4, 1 ac plot of lands from mildly affected (2 lands) and moderately affected (2 lands) large estates (>5 ac). During the year one site in moderately affected land was selected and seed-hole maps were drawn. The experiment is in progress.

H. T. R. Wijesekara, R. de Silva, N. G. Premasiri (Crop Protection Division), D. Hettiarachchi, W. A. T. L. Weerakkody & W. G. R. Subathma (WCLWD research project)

SUB PROJECT 26.5.4 STUDIES ON NUTRIENT LEVELS OF WCLWD-AFFECTED PALMS (2008)

Experiment 26.5.4.1 Studies on nutrient status of WCLWD affected palms and its seasonal variation (2008)

An experiment was started at four WCLWD-affected estates to determine the relationship between the intensity of yellowing and nutrient levels of the affected palms, progress and the pattern of yellowing with time in fertilized and unfertilized palms and to evaluate the response of affected palms to supply of nutrients. Out of the four estates, two estates were regularly fertilized (Gampola estate and Medihena estate) and the other two were unfertilized estates (Mallika estate and Nugagaha estate). The palms were selected under five categories (severely affected, moderately affected, slightly affected, apparently healthy and leaf rot affected) based on the disease index. The experiment was in single palm plot with 6 palms per each category. In unfertilized estates two sets of palms were selected from each category. A fertilizer treatment of 3.3 kg of Adult Palm Mixture (Wet and Intermediate zone) and 1 kg of dolomite will be given per palm annually. Before treatment application, leaf samples were collected from 14th frond and soils from both manure circle and center of squares up to the depth of 0 - 25cm from selected palms individually in Gampola and Mallika estates. Chemical analysis of leaf and soil samples for macro (N, P, K, Ca, Mg, S, Cl) and micro nutrients (Fe, Mn, Cu, Zn and B) are in progress.

D. M. D. I. Wijebandara, I. Herath, N. H. R. M. de Silva, K. P. A. Pathirana & R. Silva (Soil and Plant Nutrition Division)

SUB PROJECT 26.5.5 STUDIES ON ASSESSING CROP LOSS DUE TO WCLWD (2008)

Experiment 26.5.5.1 Studies on losses in developing and harvested nuts of WCLWD-affected palms

A study was commenced in four estates affected by WCLWD to identify the most susceptible stage of the coconut bunch to the disease, the pattern of nut loss along the maturity cycle of bunches, the seasonal effects on nut loss and to determine the quantitative and qualitative yield loss. Two estates are being regularly fertilized while the other two are not. Twelve palms each from five disease categories (apparently healthy, mild, moderate, severe and leaf rot) were selected using the disease severity index. The number of female flowers, button nuts/young/mature coconuts on each bunch and size of the mature nuts in terms of longitudinal and horizontal perimeters were collected from the palms once. The study is in progress.

K. P. Waidyarathne & S. Wickramarachchi (Biometry Division), D. Hettiarachchi, W. A.T. L. Weerakkody & W. G. R. Subathma (WCLWD research project)

SUB PROJECT 26.5.7 STUDIES ON MANAGEMENT OF WCLWD (2007)

Experiment 26.5.7.1 Studies on the effect of oxytetracycline on symptom expression of WCLWD-affected palms (2007)

This experiment conducted at Nugagaha watta, and Rubber watta in Kotawila was continued. Twelve palms with flaccidity and /or intense yellowing were selected in each estate and grouped randomly. Total numbers of yellow, flaccid and necrotic fronds were recorded at 3-monthly with the application of tetracycline plant formula (5g) in 5ml of distilled water as treatments. Further, the average number of nuts per palm was also recorded. Oxytetracycline has reduced the intensity of yellowing, while no change in flaccidity symptom. The experiment is in progress.

H. T. R. Wijesekara, R. de Silva & N.G. Premasiri (Crop Protection Division)

Experiment B26.5.7.2 Improvement of WCLWD affected coconut palm health through different agronomic practices

An experiment was commenced in Kekunadura estate (WL1/S4), Matara to develop a suitable package of agronomic practices to improve the health, soil fertility and prevent soil degradation of lands affected by WCLWD. The following treatments were imposed on palms as a randomized complete block design with three replicates and with 10 palms per plot.

T1 – mulch with husk + live mulch with Pureria outside manure circle + contour drains + harrowing + application chemical fertilizer at ½ rate 2 times a year.

T2 - mulch with husk + tree farming (green manure Gliricidia/wild sunflower) + contour drains + harrowing + application chemical fertilizer at ½ rate 2 times a year.

T3 - mulch with husk + cattle farming (tethering) + tree farming (green manure Gliricidia/wild sunflower) + contour drains + harrowing + application chemical fertilizer at ½ rate 2 times a year.

T4 – Control

The experiment is in progress.

S. H. S. Senarathne, M. J. I. Costa & K .D. D. Appuhamy (Agronomy Division)

PROJECT B26.5.8 STUDIES ON THE CONTROL OF LEAF ROT DISEASE OF COCONUT (2000)

Experiment B26.5.8.1 Studies on the effect of nutritional condition on leaf rot affected palms (2006)

The experiment 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, Kamburugamuwa continued. 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. 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 of tapering, number of nuts in bunches, extent of leaf rotting) of the palms was recorded at 3-monthly intervals.

Leaf analysis indicated that both healthy and affected palms were deficient in potassium, magnesium, calcium, sodium, manganese and zinc. Phosphorus and Copper levels in both categories exceeded that of sufficiency range. No clear association between land suitability class and fresh incidence of leaf rot disease or any improvement of palm health of experimental palms was observed. The experiment was terminated.

Table 13. Effect of application of compost on fresh infection of bud leaf by leaf rot disease in different land suitability classes

Time (months)	Percent bud damage			
	Abensuhena estate (S2)	Batadola estate (S2)	Batadola (S4)	Medahena (S3)
0	100	100	100	100
3	67	0	15	67
6	67	67	50	52
9	67	67	50	52
12	82	67	50	67
15	50	82	67	82
18	70	50	30	52

H. T. R. Wijesekara, A. Tennakoon, R. de Silva, C. Wanigasekara & N.G. Premasiri

Experiment 26.5.7 Studies on the effect of antagonists on leaf rot affected palms (2007)

An experiment was conducted in three estates; Siriwardena watta, Henwala, Karuwalabedda watta, Kamburugamuwa and Batadola estate, Kottegoda to determine the effect of antagonistic fungi on the disease. Leaf rot affected palms were marked and 24 palms in mild and moderate stages were selected for treatment. Palms were randomly grouped for three treatments; spore suspensions of *Aspergillus niger*, *Trichoderma viridae* and control each containing 8 palms. Bud leaf of each palm was marked for future reference at each treatment occasion. In the first instance bud leaf and rotten portions of adjacent 3 fronds were removed to reduce initial inoculum. Spore suspension of 10^6 was sprayed onto the bud region to wet thoroughly. Treatments were repeated at 3-monthly intervals and disease condition of newly emerged fronds

was recorded. The experiment was terminated due to no reduction in the disease condition of treated palms compared to the untreated control (Fig. 7).

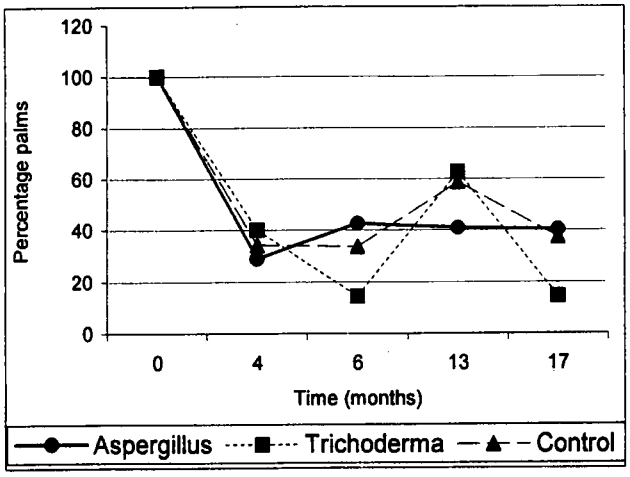


Fig. 7. Percentage palms with bud damage when treated with fungi Aspergillus and Trichoderma and untreated control.

H. T. R. Wijesekara, R. de Silva & N.G. Premasiri

Experiment 26.5.8 Studies on effect of large scale application of recommended dose of fungicides on leaf rot disease (2008)

Although recommendation was made to apply Tebuconazole EW250 (Folicur) for the control of leaf rot disease, a large scale pilot study has not been conducted. One study site in Denipitiya area was selected and palms were indexed as per the index developed. Affected bud leaf and affected portions of adjacent 2 - 3 fronds of palms to be treated and control were cut and removed prior to the drenching of 11 fungicide solution (10ml/ l). One round of treatments was applied. The experiment is in progress.

H.T.R. Wijesekara, R. de Silva & N.G. Premasiri

3. CROP PROTECTION SERVICES

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 3486 vials were sold to the growers and CCB Regional Offices.
c. Chemical control: A total of 56 litres of monocrotophos was issued mainly to CRI estates. 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	South -ern	Eastern	Total
Bracon hebetor	3500	233500	40750	3500	433450
Goniozus nephantidis	0	42950	1750	0	281250
Brachymeria nephantidis	2800	42700	13650	0	44700
Total	6300	360800	62000	4350	59150

4. TRAINING AND 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.

5. 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.

ANNUAL REPORT OF THE BIOMETRY DIVISION

Officer-in-charge J M D T Everard, MSc

1. GENERAL

Biometry Division assisted research divisions in all aspects, statistical advice, designing field experiments, analyzing data and conducting surveys. The network of CRI was upgraded by increasing the bandwidth up to 256 kbps. The mail system and web site were transferred to Sri Lanka Telecom for better management with improved efficiency of usage. The computer network system was administrated efficiently with 34 workstations along with updating institute's website (www.cri.lk) throughout the year. Four agro-meteorological stations and three rainfall stations were maintained and while collecting and collating meteorological data on daily basis.

Island wide consumer survey on coconut and coconut oil was successfully carried out collaboratively with the Divisional Secretaries and selected Grama Niladaries and data capture survey on coconut yield in collaboration with the Regional Managers and Coconut Development Officers of Coconut Cultivation Board.

2. STATISTICAL ASSISTANCE

Data analyses of various long-term and short-term field experiments, lab experiments, and surveys of various divisions were carried out. Undergraduates and postgraduates from the different universities were also assisted in statistical analysis of their research projects undertaken at the CRI.

(K P Waidyarathna, J D J S Kularatna, and W E R C Fernando)

Research divisions were assisted in designing their field experiments commenced during the year.

(K P Waidyarathna, Peiris)

3. COMPUTER RELATED WORK

The divisional staff attended to following activities related networking and computer services. The website (www.cri.lk) was maintained and updated routinely.

(J D J S Kularathna)

Climate database of the coconut growing areas and yield database of CRI estates were duly updated.

(K P Waidyarathna and S S Rajapakse)

All research divisions were continuously assisted on the use of Internet and e-communications.

(K P Waidyarathna, S S Rajapakse, J D J S Kularatna and W S Wickramarachchi)

Co-ordinated in developing Computer programs for managing databases and analyzing data for administrative functions of the institute were aptly coordinated.

(W S Wicramarachchi)

Hardware and software of computers in the institute were daily maintained.

(S S Rajapakse, W S Wickrmarachchi and J D J S Kularatna)

Collected and collated weather variables in seven meteorological stations of the CRI throughout the year.

(J D J S Kularatna, W B P Fernando, J H U Jayamaha and J H Premarathna)

Provided assistance for maintaining and processing MAS activities of the Institute.

(J D J S Kularatna)

Updated the national data base of bimonthly coconut yield by CDO ranges.

(W K M K Herath)

4. RESEARCH PROJECTS

Thrust Area: **Crop Production/Improvement/Processing**
Project 1: **Yield Capturing Survey**
Objective: **To identify yield variability between districts and seasons for providing information for policy makers in the coconut industry.**
Methodology:

Data capture survey was continued with the assistance of Coconut Development Officers (CDOO) of the Coconut Cultivation Board (CCB). Five estates were identified from each CDO range covering all CCB regions excluding those in the Northern Province. In addition to those estates selected data were also collected from the estates selected from Puttalam, Gampaha and Kurunegala CCB regions by the divisional staff.

Results

Annual national coconut production (ANCP) of Sri Lanka was 2,871 million nuts in 2008, and this was 3.4% more than the predicted national yield for the year. ANCP in 2008 is 2.6% more compared to 2007 (2,798 mill. nuts). The comparison of predicted and actual bimonthly yield is shown in Fig. 1.

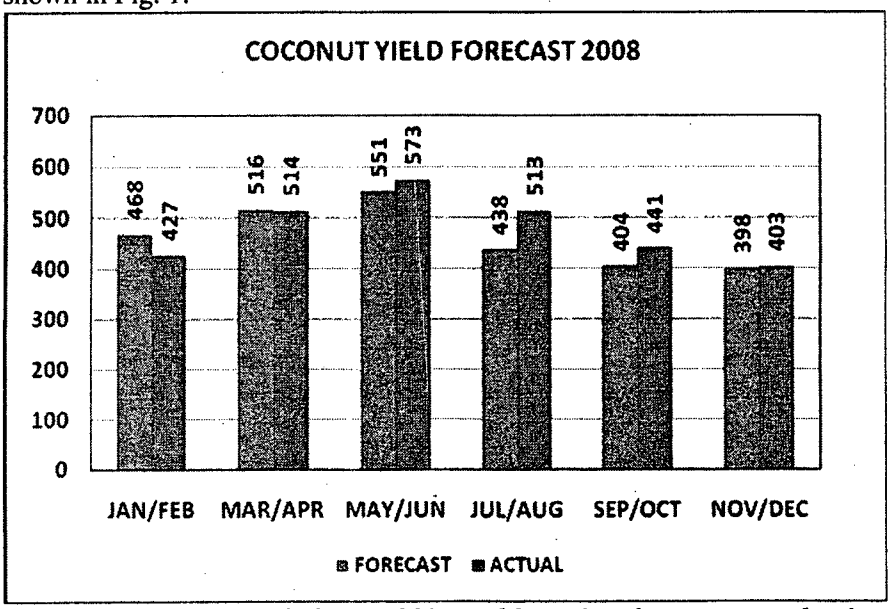


Figure 1. ***Predicted and observed bimonthly national coconut production in the year, 2008.***

The contribution to the ANCP by CCB regions in 2008 is shown in Table 1. According to the table, the best per palm yields 81 and 77 nuts per palm were reported from Monaragala and Amparai CCB regions respectively. National nuts per palm average for the year 2008 was 56.

Palm yields reported from Galle and Matara CCB regions were the poorest.

Bimonthly pattern of per palm yield varied among CCB regions. However, many CCB regions recorded high crops during May/June period. The regions belonged to Dry Zone of Sri Lanka (Amparai, Anuradhapura, Hambantota, Monaragala and Pollonnaruwa) reported higher yields during January - April while other regions experienced high yield during May-Aug in 2008.

Table 1. ***Observed bi-monthly coconut yields (nuts/bearing palm) in different CCB regions during the years 2008.***

CCB Region	Jan /Feb	Mar/ Apr	May /Jun	Jul /Aug	Sep /Oct	Nov /Dec	Total (nuts/p/y)
Amparai	13	13	13	13	13	12	77
Annuradapura	11	10	10	9	10	10	61
Galle	7	9	9	8	6	5	44
Gampaha	5	8	11	11	9	6	50
Hambantota	9	10	9	8	7	7	50
Kalutara	8	9	11	13	8	8	57
Kegalle	6	9	10	9	7	5	47
Kuliyapitiya	7	9	10	10	8	8	52
Kurunegela	6	10	10	10	8	6	50
Marawila	11	12	13	11	10	10	67
Matale	7	8	8	9	10	10	53
Matara	7	9	10	8	6	5	46
Monaragala	15	13	15	11	13	14	81
Polonnaruwa	10	10	10	9	9	7	56
Ratnapura	8	7	9	9	7	8	50
Other areas	8	9	10	9	8	8	53
National	9	10	11	10	9	8	56

Table 2. *Distribution of coconut yield (million nuts) by CCB regions in 2008*

CCBR	Jan/Feb	Mar/Apr	May Jun	Jul/Aug	Sep/Oct	Nov/Dec	Total
Amparai	9.18	9.36	9.05	8.62	8.79	8.47	53
Annuradapura	22.25	20.04	19.12	18.14	19.54	18.31	117
Galle	14.10	18.84	19.69	15.49	11.33	10.85	90
Gampaha	32.22	48.10	67.90	65.31	51.84	37.68	303
Hambantota	25.57	28.74	27.04	22.90	21.51	21.93	148
Kalutara	21.88	27.88	33.18	33.94	21.51	21.00	158
Kegalle	12.96	19.53	22.90	19.15	15.78	10.55	101
Kuliyapitiya	52.36	68.79	75.41	71.45	58.10	56.69	383
Kurunegela	57.64	87.42	97.32	87.37	70.41	60.56	461
Marawila	69.16	71.97	79.26	61.15	60.65	56.04	398
Matale	18.30	19.00	20.12	22.98	23.02	21.92	125
Matara	15.11	19.38	22.32	16.65	13.09	9.76	96
Monaragala	29.19	24.86	25.28	18.62	22.39	26.16	146
Polonnaruwa	10.05	9.69	9.43	8.46	8.10	7.20	53
Ratnapura	18.45	17.80	20.62	21.18	16.66	18.28	113
Other areas	18.76	23.01	24.48	21.01	18.86	17.81	124
National	427.00	514.39	573.10	512.43	440.59	403.22	2871

Distribution of coconut production by CCB regions to the national yield in 2008 at bimonthly intervals is shown in Table 2. Comparing to 2007, the coconut production during Jan - Feb period was low in 2008 but was more in both last 2 crops in 2007. Monaragala CCB regions showed clear difference among all by yielding 50% more nuts during 2008 than in 2007. Yet the contribution of CCB regions in the coconut triangle (Gampaha, Marawila, Kurunegala and Kuliyapitiya) was 53% of the ANCP.

(K P Waidyarathna, 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**
Objective: **Prediction of Annual and bi-monthly national yield for 2009**

Results:

Using the integrated crop forecasting model (CRI Annual Report, 2005), which incorporates climate effect and technology effect, the national yield for 2009 was predicted as 2,859 million nuts. As the error margin is 5%, this figure is liable to vary between 2716 - 3002 million nuts. Breakdown of national coconut production on bimonthly intervals was made considering the monthly rainfall intensity and distribution in 2006 and 2007 within main agro - ecological regions in coconut growing areas (Fig 2).

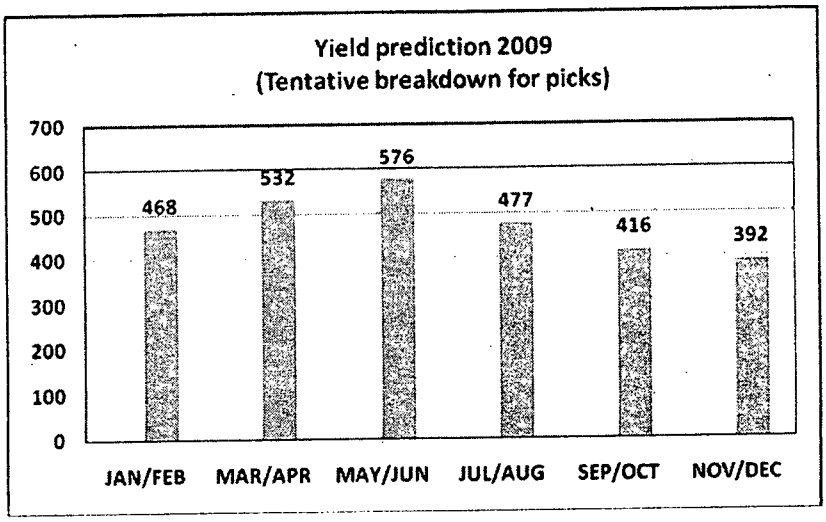


Figure 2. ***Predicted bi-monthly national yields of coconut for the year, 2009***

(K P Waidyarathna)

Thrust Area: **Crop Production/Improvement/Processing**

Project 3: **Identification of consumption patterns of coconut nuts and coconut oil**

Objective: **To identify the pattern of consumption rate of coconuts and oil by districts.**

This information would be useful to control imports of substitute oils, compute cost of living indices by districts and identify the domestic consumption of coconuts in Sri Lanka.

Methodology:

The consumer survey on the coconuts and coconut oil was conducted island-wide in selected DS divisions with the assistance from the Divisional Secretaries and Grama Niladaries from January 2007. The amount of coconut oil and fresh nuts consumed by a family was monitored for five weeks by sampling ten families selected within a Grama Niladari Division. Data collection was assisted by Grama Niladhari officers (GNN) of respective regions. Data were submitted to Biometry Division by GNN. The Grama Niladaries assisted in the programme were honoured by awarding certificates of appreciation.

Results

Table 3. ***Consumption rate of coconuts and coconut oil during 2006 - 2008 in 19 districts***

District	2006		2007		2008	
	Consumption rate/person/year		Consumption rate/person/year		Consumption rate/person/year	
	Number of nuts	Number of oil bottles	Number of nuts	Number of oil bottles	Number of nuts	Number of oil bottles
Anuradhapura	111.6	7.3	103.11	8.22	89.87	7.79
Badulla	62.1	8.2	57.25	9.71	50.65	9.40
Colombo	90.0	6.9	75.82	7.93	83.09	6.60
Galle	104.4	6.8	99.85	6.74	87.80	6.01
Gampaha	81.9	6.6	102.14	6.72	88.35	6.56
Hambantota	126.9	6.7	128.51	5.07	115.58	4.40
Kalutara	101.7	7.7	99.49	6.72	96.43	6.17

Kandy	98.1	7.1	82.65	7.39	73.77	6.84
Kegalle	131.4	6.1	111.06	6.56	94.14	5.54
Kurunegala	151.2	6.5	143.59	6.11	134.98	5.48
Matale	101.7	8.1	101.45	7.71	89.52	6.95
Matara	106.2	6.7	105.32	5.74	93.86	5.08
Monaragala	101.7	8.6	96.55	8.22	85.36	7.33
Nuwara Eliya	64.8	7.5	66.64	9.35	59.09	8.00
Polonnaruwa	103.5	5.7	101.17	7.90	104.61	6.57
Puttlam	124.2	8.5	125.72	7.72	102.57	6.64
Ratnapura	120.6	7.6	112.87	7.44	96.99	5.93
National mean SE	104.8 ± 3.5	7.2 ± 0.2	101.0 ±4.75	7.3 ±0.26	92.65± 4.56	6.46± 0.28
CV (%)	21.6	11.5	20.1	15.2	21.28	18.07

The percapita nut consumption, both as fresh nuts and coconut oil were low in 2008 comparing to 2 previous years.

The total number of nuts utilized as fresh nuts alone in 2008 is 1,879 million. This is 65% of the country's total annual national production. Similar to the fresh nut consumption, the rate of oil consumption has also decreased to 6.46 bottles. Almost all districts showed low consumption of both fresh nuts and oil during last year compared to 2007. However, the variability of both nut and oil consumptions between districts was increased as compared to 2007.

According to the Table 3, the consumption rate of fresh nuts was exceptionally high in Kurunegala and Hambanthota districts. High rate of oil consumption were reported from Badulla and Nuwara Eliya districts while the rate of oil consumption at Hambantota district was low.

Table 4. ***Monthly consumption rate of coconuts and coconut oil during the year 2008.***

Month	2008	
	Consumption rate/person/month	
	Number of nuts	Number of oil bottles
January	7.29	0.52
February	7.61	0.44
March	6.71	0.55
April	7.57	0.66
May	8.85	0.62
June	7.47	0.52
July	7.81	0.52
August	7.61	0.54
September	8.58	0.50
October	7.56	0.53
November	7.55	0.56
December	8.03	0.50
Annual mean ± SE	92.65 ± 0.16	6.46 ± 0.016
CV	7.30	10.59

Table 4 shows the monthly consumption rate of fresh nuts and coconut oil in the country. According to the Table 4, monthly consumption of nuts shows a low variability than oil. The oil consumption is comparatively higher during April and May, which may be due to religious and cultural events that fall in these months. The nut consumption was highest again during May and September.

(K P Waidyaratne, J D J S Kularatna, S SRajapakse, S Wickramarachchi, W E R C Fernando, W B P Fernando, W K M K Herath, U I Abeysinghe, J H U Jayamaha and J H Premarathna)

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 farmers' 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: (S_1 - S_4) were selected.**

Results:
The annual yield per palm obtained by monthly harvesting is significantly higher than bimonthly harvesting in all land suitability classes (Tab. 5)

Table 5 : ***Difference in number of female flowers, and nuts and percentage setting between monthly and bimonthly harvesting during the period 2005 - 2008.***

Frequency of harvesting	Female flowers	Nuts	Setting %
1 M	295 A	99 A	0.39
2 M	246 B	79 B	0.37
Probability of significance	0.030	0.0005	NS

According to the data in Table 5 nut setting percentages are not significantly different between two frequencies of harvesting in all LSC. However, number of female flowers produced show a significant increase in palms subjected for monthly harvesting.

Table 6. ***Percentage difference in nut number after one month and two month harvesting in the 3- year period. (2006-2008)***

LSC	Location	2006			2007			2008		
		1M	2M	% change	1M	2M	% change	1M	2M	% change
S1	Pambala	133	77	73	111	69	61	103	79	66
S1	Marawila	151	154	-1	163	153	7	150	157	-8
S1	Sirigampola	111	85	31	94	80	18	102	86	31
	AVG S1	**132**	**105**	**25**	**123**	**101**	**22**	**63**	**55**	**15**
S2	Madurankuliya	95	80	19	*	*	*	*	*	*
S2	Kuliyapitiya	94	67	40	75	55	36	67	63	6
S2	Nattandiya	109	81	35	101	86	17	78	71	19
	AVG S2	**99**	**76**	**31**	**88**	**71**	**25**	**28**	**25**	**14**

S3	Dunkannawa	134	90	**49**	107	92	**16**	94	77	**5**
S3	Mangalaeliya	98	96	**2**	93	95	**-2**	52	38	**37**
S3	Kobeigane	71	48	**48**	75	48	**56**	62	52	**14**
	AVG S3	**101**	**78**	**29**	**92**	**78**	**17**	**39**	**32**	**20**
S4	Dunkannawa	128	109	**17**	124	110	**13**	51	53	**-4**
S4	Bingiriya	97	73	**33**	103	69	**49**	32	24	**33**
S4	Sembukattiya	113	86	**31**	94	67	**40**	29	25	**16**
	AVG S4	**113**	**89**	**26**	**107**	**82**	**30**	**37**	**34**	**10**
GRAND MEAN		**111**	**87**	**28**	**104**	**84**	**23**	**43**	**37**	**15**

* Data not available

The annual yield per palm at 1M picking was significantly higher than at 2M picking in all farmers' fields (Table 6). The percentage increase varied from location to location. This difference was also evident in locations of same LSC. Of the four coconut land suitability classes (S_1 – S_4) the highest percentage increase was observed in S_2 followed by S_4 and all estates having S_2 and S_4 both soils showed high percentage increase. The rates of increase were low during 2007 compared to2006 in most LSCs.

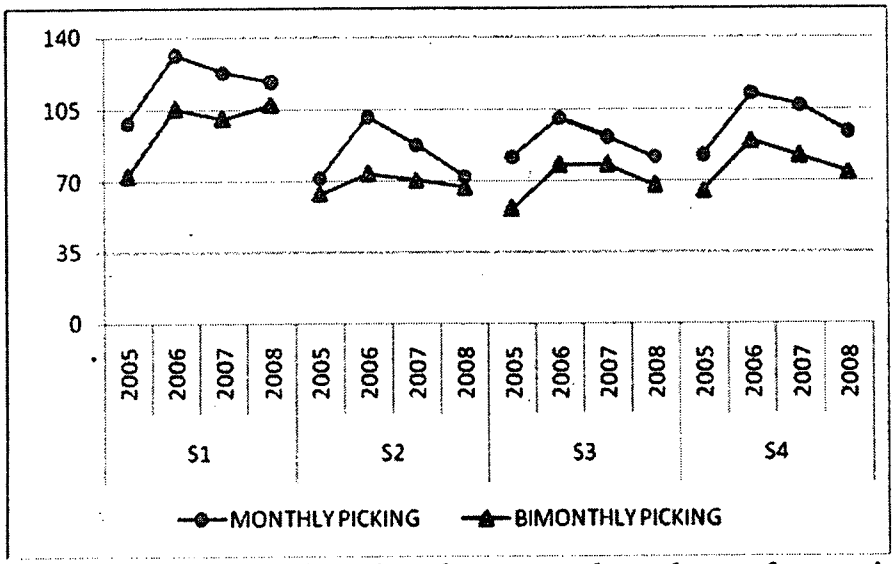


Figure 3. ***Distribution of number of nuts per palm under two frequencies of harvesting during 2005 - 2008***

The distribution of per palm yield at two frequencies of harvesting during 2005 - 2008 is shown in Figure 3. According to the Figure 3, both frequencies of harvesting indicate a decreasing pattern along with time in all LSCs. As all farmers fields were selected within same agro-ecological regions, the similar pattern of changing per palm yield may be attributed to climatic effect.

(K P Waidyaratna, J D J S Kularathna, , W E R C Fernando, W K M K Herath , W B P Fernando and J H U Jayamaha)

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), Anuradhpura, 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 intervals from 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 scars – MF, and nuts having mite scars - MI), and (b) nut size (full priced nuts – S1 and half priced nuts – S2, barren and deformed - BD). The full priced nuts were defined as the nuts, which could be sold at full price and half priced nuts were those referred as nuts, which are generally sold at half price of a nut. This was determined in consultation with the owner of the estate or the buyer. Nuts that do not belong to full or half priced were named as either barren or deformed. Those nuts can not be sold even if they are not infected. Barren nuts are those with no water inside. Deformed nuts are those which do not belong to either normal shape or barren.

Results

Table 7. ***Percentage distribution of nuts by different categories of mite damage in three districts during 2008***

Loc	Month	S1	S2	DB	S1	S2	BD
Anuradhapura	February	18.11	0.06	0.00	61.86	18.65	1.37
	April	2.09	0.00	0.00	69.06	25.47	3.45
	June	1.45	0.00	0.00	70.29	20.24	8.00
	August	2.30	0.54	0.00	65.61	24.59	6.87
	October	8.22	0.26	0.07	71.27	16.73	3.49
	December	15.16	0.03	0.03	68.57	14.24	1.93
Kurunegala	February	22.92	1.07	0.00	65.24	9.55	1.22
	April	10.84	0.51	0.50	64.21	18.29	4.73
	June	5.37	0.10	0.13	67.52	24.14	2.72
	August	10.77	0.23	0.00	69.37	17.85	1.75
	October	18.66	0.00	0.59	69.94	9.74	1.03
	December	35.56	0.86	0.00	51.00	11.92	0.71
Puttlam	February	32.29	0.00	0.10	57.43	9.35	0.82
	April	10.79	0.00	0.06	75.17	10.29	3.73
	June	9.49	0.14	0.22	72.99	11.52	5.61
	August	21.37	0.00	0.10	66.47	7.81	4.18
	October	27.74	0.00	0.00	66.65	3.47	2.09
	December	43.17	0.00	0.00	55.77	0.72	0.33

Table. 7 clearly indicates that percentage nuts of mite infested categories are higher than that in mite free categories. Percentage infection varied both spatially ($p<0.001$) and temporally variations ($P<0.0001$). Improving that intensity of mite damage changes by districts as well as seasons within a year.

Results of Table 8, shows that percentage of mite infested nuts during the period from February to December differs significantly over months.

Table 8. ***Bi-monthly averages of percentage total mite infection through out the period***

Month	**Percentage mite infested nuts**
February	76.03 C
April	91.32 A
June	94.21 A
August	87.91 AB
October	81.31 BC
December	68.20 D
LSD	7.8

The highest damage level was recorded in June, followed by April and August in all three locations. Anuradhapura area showed the highest percentage of mite infected (91.9%) during the period (Table 9) among all infested zones

Table 9. ***Mean percentage mite infection in MIZs***

MIZ	Percentage mite infested nuts
Anuradhapura	91.90 A
Kurunegala	81.51 B
Puttlam	76.12 B
LSD	3.36

The damage was changing over time, but these changes were different in different categories (S1, S2 and DB). However the changing pattern of a particular category was similar in all three locations.

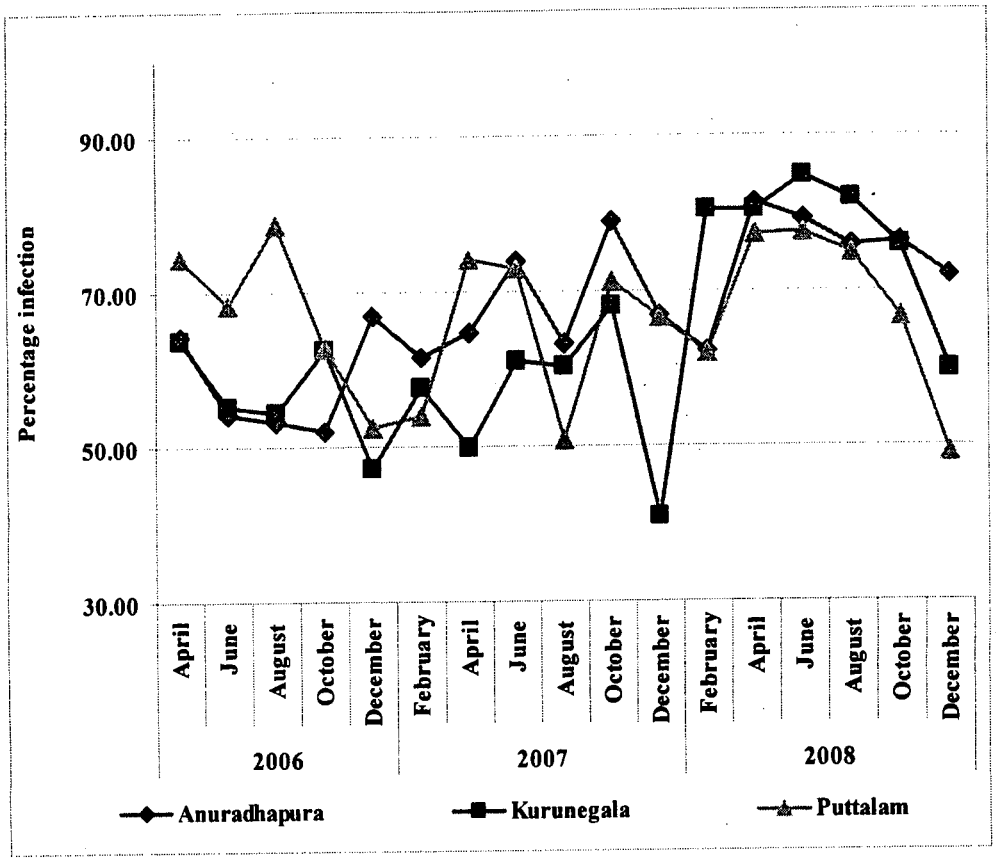


Figure 4 . ***Distribution of percentage mite infested full priced nuts in three MIZ during the period, 2006 - 2008***

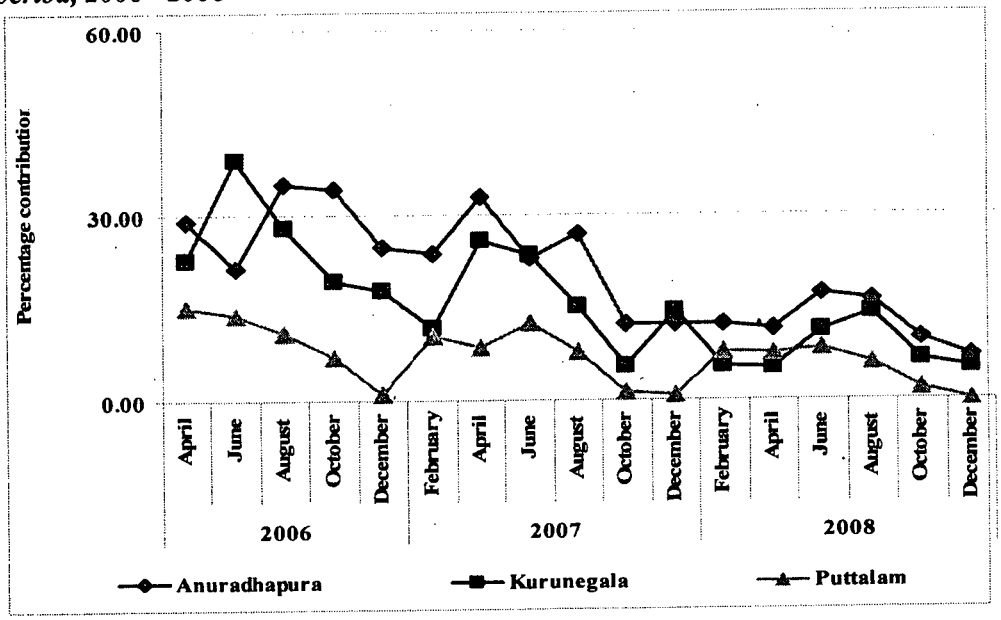


Figure 5 : ***Distribution of percentage mite infested half priced nuts in 3 MIZs during the period 2006 - 2008.***

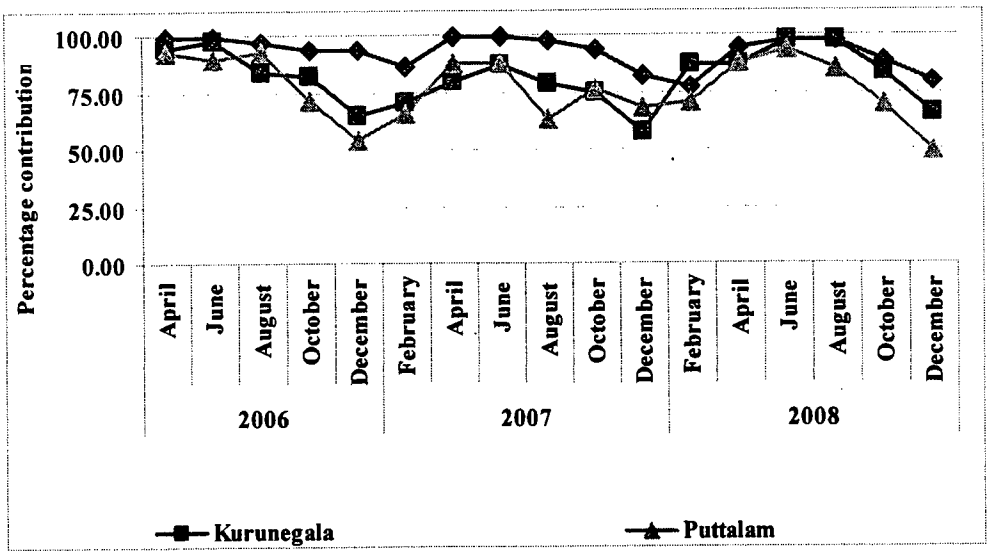


Figure 6: ***Distribution of percentage mite infested nuts (S1 + S2 +BD) in 3 MIZs during the period 2006 - 2008***

According to Fig. 4 and Fig. 5 the time trends of two different categories are in opposite direction. Percentage of total infestation clearly shows the seasonality (Fig. 6).
Irrespective of the year and region percentage mite infestation shows a peak during May June period. The economic loss is defined as the financial loss to the farmer due to mite infested barren/deformed (BD) nuts and half priced nuts. Therefore the trend analysis was separately done for each category and each MIZ (Tab 10).

Economic loss = DB + 1/2 (S2MI)

Table 10. ***Directional changes of percentage of mite infested categories along the period***

	Half prized		Total infested		Economic loss	
MIZ	**slope**	**Probability of significance**	**slope**	**Probability of significance**	**slope**	**Probability of significance**
Anuradhapura	-1.44	0.000	-0:666	0.064	-1.31	0.000
Puttlam	-0.582	0.008	-0.787	0.268	-0.363	0.063
Kurunegala	-1.46	0.000	-0.215	0.731	-0.901	0.000

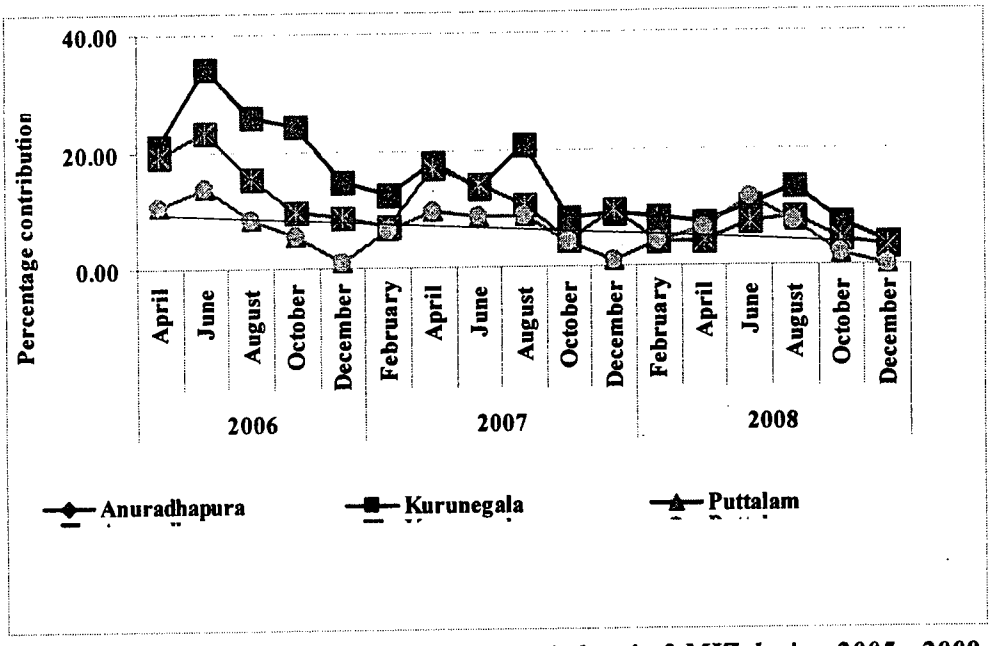


Figure 7. ***Distribution of percentage economic loss in 3 MIZ during 2005 - 2008.***

Similar to the distribution of percentage of S2 MI, percentage economic loss to the grower shows significant down-ward trend in all three mite infested zones during the period.

Results of trend analysis further confirmed that the percentage of S2 MI nuts are significantly decreasing over time in all MIZs so as do percentage of total infection (TMI)

Trust Area : Crop Production
Project 6: Temporal variability of copra conversion factor
Objectives : To identify the stability of copra conversion factor along bi-monthly intervals.
To estimate the copra outturn of an estate using nut numbers.
Location : Four blocks of 15 palms each at Ratmalagara estate.
Methodology: Nuts are harvested bimonthly for collection of data. Total nut count and fresh weight of selected samples are taken separately for each block. Dehusked nuts weight, and split nut weight are taken from the same sample prior to copra preparation. Copra is prepared in four separate cages and weighed separately.

Results :
The copra content per nut was not significantly different in nuts harvested at bimonthly intervals, but fresh nut weight varied significantly. According to the results shown in Fig. 8 (a, and b) the fresh weight and copra weight per nut varied within a very narrow range. A correlation analysis was therefore, carried out to evaluate the linear dependency of these parameters (Tab 11).

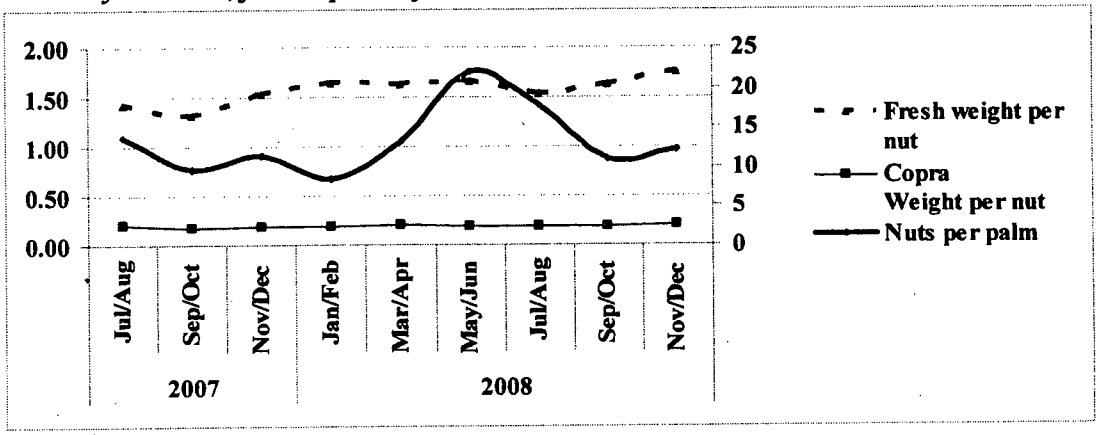
Table 11. ***Pearson correlation matrix for all possible combinations of nuts per palm (NP). Fresh nut weight (FW), De-husked nut weight (DW), spit nut weight (SW) and copra weight per nut (CW).***

	FW	DW	SW	CW
NP	0.19 NS	0.11 NS	0.10 NS	-0.08 NS
FW		0.83 ***	0.82 ***	0.44 **
DW			0.82 ***	0.50 ***
SW				0.56 ***

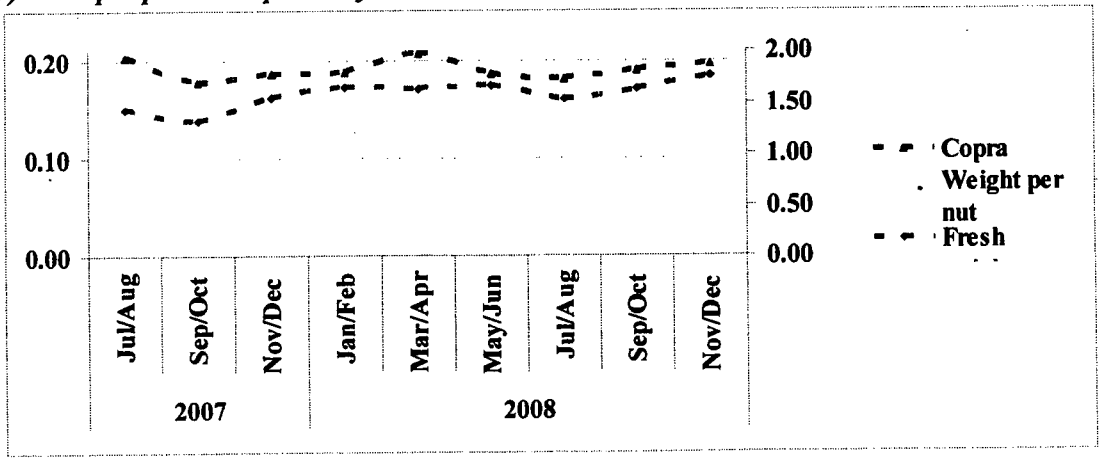
*** - Significant at 1% level ** - Significant at 5% level

According to Table 11 the number of nuts per palm does not correlate significantly with other parameters, fresh weight, de-husked weight, split nut weight or copra weight per nut. However, copra content of a nut is significantly correlated with both de-husked nut weight and split nut weight.

Figure 8 ***Distribution of nuts per palm, fresh weight of a nut and copra weight along bimonthly intervals, for the period from Jul 2007 to December 2008.***



a) Nuts per palm and per nut fresh nut



b) Distribution of fresh weight and copra weight along bimonthly intervals during 2007 and 2008.

5. 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 properly maintained. Daily recordings were taken throughout the year on rainfall (mm), air temperature maximum and minimum (^{0}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 Stevension 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.

5.1 Climate at Bandirippuwa Main Research Center (BRC) (Table 11)

Rainfall: The total annual rainfall for the year was 2451 mm. This amount is 77.12% higher than the rainfall received during 2007 (1383.8 mm) as well as 43.8% higher than that of last ten year average rainfall (1998-2007). The rainfall during Feb-Apr period is exceptionally higher than the ten year average. The whole year was comparatively wetter than the previous year, 2007.

The percentage contribution of rainfall for three monthly seasons, Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec. were respectively 31.2, 25.9, 12.1 and 30.8.

Temperature: The monthly maximum temperature ranged from 30 ^{0}C during July to 31.6 ^{0}C during February. From January to August, 2008 the maximum temperature was lower than the ten year averages for the similar period.

The monthly minimum temperature ranged from 21.1^{0}C during February to 24 ^{0}C during both July and August. The maximum and minimum mean average temperatures for the year in 2008 were below the ten year averages from 1998-2007.

Sunshine: Sun shine hours ranged from 3.7 hrs/day during March to 7.6 hrs/day during February with a mean 6 hrs/day. In 2007, the highest sunshine hours were recorded during March but in 2008 the sun shine hours recorded during March was the lowest. This may be due to exreamly heavy rainfall received during March in 2008. The year showed reduced sunshine hours compared to long-term average of 7.2 hrs./day.

Evaporation: The lowest evaporation was recorded in April and October. The highest evaporation was recorded in January, August, September and December. The evaporation rate observed in each month of 2008 is lower than long term respective monthly averages except in November.

Relative Humidity: The average relative humidity in the morning fluctuated between 82% during September and to 89% during September and to 89% during March. In the afternoon it varied around 77% during January to 85% during March.

5.2 Climate at Ratmalagara Research Center (RRC) (Table 12)

Rainfall:
Total rainfall for the year was 2093 mm. It was a 23.6% increase compared to the proceeding 10 - year mean annual rainfall(1998-2007). Rainfall during first quarter of the year showed a 91% increase comparing to the average of last 10 - years average of first quarter. Rainfall during last quarter also increased by 28%. The contribution from three monthly seasons to the total was 17.8%, 20.2%, 11.6%, and 50.4% respectively.

Temperature:
The monthly maximum temperature was 31.6 ^{0}C and it varied from 31.0^0 C during August to 32.8 ^{0}C during February. Lowest minimum temperature was 21.6 ^{0}C during January and the highest minimum temperature was 25.2 ^{0}C during May. Overall both maximum and minimum temperature averages for the year have dropped down from the last 10 year average.

Sun shine (hrs):
Sun Shine hours ranged from 4.8 hrs during November to 7.4 hrs during May. The mean daily Sunshine duration of the year is greater than that of last 10 year average.

Evaporation:
Evaporation values ranged from 1.9 mm during November to 2.9 mm during February and May with a monthly mean of 2.6 mm.

Relative Humidity:
Relative humidity in the morning varied from 82% during July to 90% during November. In the afternoon it was varied from 60% during February to 75% during Jun. The mean daily RH for the year was 86% in the morning and 70% in the afternoon.

5.3 Climate at Ambakelle Genetic Research Center (IGRC) (Table 13)

Rainfall:
The annual rainfall of 2008 was 1612.4mm which is 12.8% increase than the last year's average annual rainfall of the station. Contributions of three monthly seasons to the annual rainfall were 32.8%, 14%, 12.5% and 40.7%. The Significant increase (185%) was recorded in first quarter rainfall compared too past ten year average of corresponding figure.

Temperature:
Temperature varied with the mean annual minimum temperature around 23.2 ^{0}C and maximum temperature equals to 31.1 ^{0}C. Both figures were comparatively lower than the similar figures of past ten year averages. The maximum temperature ranged from 28.6 ^{0}C during January to 32.2 ^{0} C May. The minimum temperature varied between 21.7 ^{0}C during January and 25.1 ^{0}C during May.

Evaporation:
The mean evaporation for the year was 2.8 mm which is 20% less than past ten year average of daily evaporation. The lowest evaporation was recorded during November and the maximum evaporation was during September and October.

Relative humidity:(RH)
Mean annual relative humidity for morning and afternoon did not show significant different from long term averages. However, the minimum RH during morning time was recorded as 79% in June and September. The morning RH was highest during January. The maximum and minimum RH during afternoon was recorded in April and September respectively.

5.4. Climate at Maduru Oya Seed Garden (Table 14)

Rainfall:
The mean annual rainfall for the year was recorded as 1682.6 mm. Not like in all other sub stations of CRI, this station has received comparatively lower rainfall in 2008 than 2007 rainfall as well as than average of rainfall of past ten years of the station. The Contributions of three monthly seasons to the annual rainfall were 32%, 5%, 17.2% and 45.8%. According to the figures, nearly 55% reduction in second quarter rainfall than average rainfall of past ten year was observed.

Temperature:
Mean maximum and minimum temperatures for the year was 30.0^{0}C and 22.9 ^{0}C respectively. Maximum temperature was lowest (30.4 ^{0}C) during May while minimum temperature was lowest (20.6 ^{0}C) during March .Maximum and minimum temperature as highest respectively during May and July.

Sun shine:
Mean sunshine duration during the year was 5.1 hrs/day and it varied from 4.2 hrs/day during March to 5.6 hrs/day during August.

Evaporation:
Mean daily evaporation rate, recorded for the year was 4.9 mm. It varied from the minimum 3.7 mm during February and maximum 5.4 mm during October and November.

Relative Humidity:
Relative humidity in morning and afternoon showed comparatively higher figures (80% and 65%) than past ten year average of the same period. In morning time, the lowest RH was recorded as 66% during June and the highest was 92% during January. In the afternoon it was lowest (54%) during September and the highest (76%) during December.

5.5 Rainfall at Poththukulama Reseach Centre, Walpita Estate, and Pallama Genetic Resource Centre (Table 15)

The total annual rainfall of PRS, WE, and PGRC were (respectively) 1677.1 mm, 2956.7 mm and 1781 mm for the year. All three stations showed higher rainfall during the year than the past ten year averages

The contribution form three monthly averages were not similar in three stations. The percentage contributions for Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec were 29.7, 17.9, 12.8 and 39.6 in PRS, 21.4, 30.2, 12.8 and 35.6 in WE, and 28.9, 21.3, 11.2 and 38.5 in PGRC.

In all three rainfall stations, the rainfall recorded during March showed significant increase than long-term average.

A bimonthly distribution during 2008 of four agree-meteorological stations and three rainfall stations was shown in figures 9 and 10 respectively.

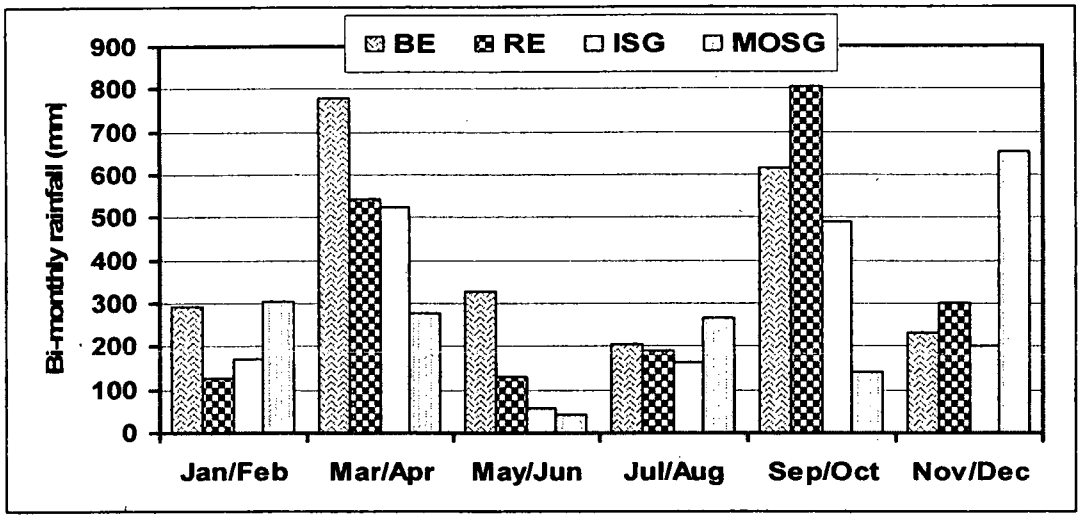


Figure 9. ***Bi-monthly rainfall distribution in 2008 in BE, RE, ISG and MO***

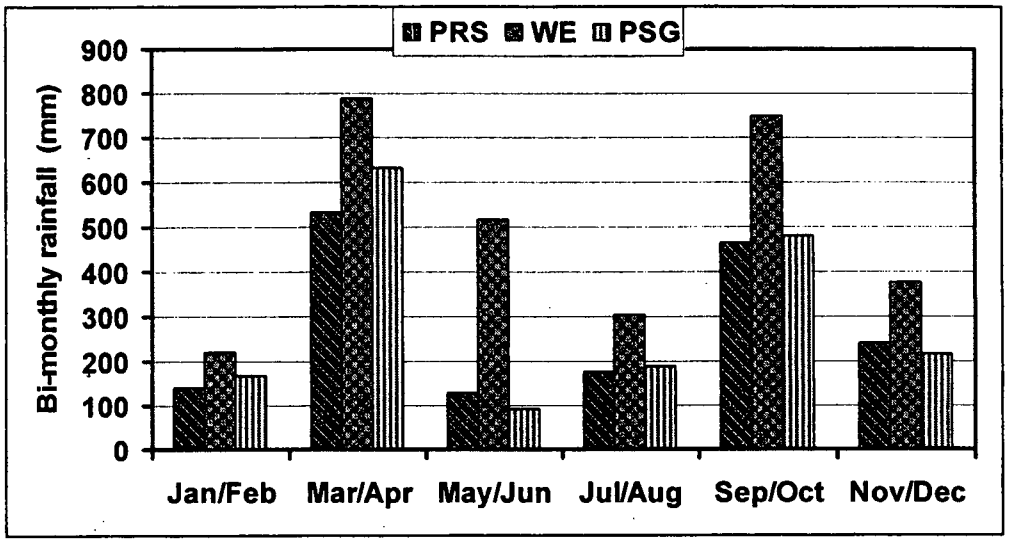


Figure 10. ***Bi-monthly rainfall distribution in 2008 in PRC, WE and PGRC***

Acknowledgements

The assistance and co-operation given by the District Secretaries, Divisional Secretaries, Grama Niladareis and their staff towards consumer survey and by all the Regional Managers, Coconut Development Officers and Mr. M D Karunathilaka, Manager (M and E), NLDB towards to carry out the data capture survey are gratefully appreciated. Thanks are also due to co-operation and assistance extended by all staff members of the Biometry Division to complete this report.

Table 12. ***Monthly climate variables in Bandirippuwa (BE) Main Research Centre in 2008 and 10-year average***

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2008	40.8	251.9	472.3	307.2	124.9	201.8	84.8	119.8	93.1	522.7	180.0	51.4	2450.7
	1998-2007	67.1	43.1	99.9	186.3	190.1	131.7	69.5	79.5	122.3	412.4	227.9	74.7	1704.5
Tmax (°C)	2008	30.7	31.6	31.2	31.3	31.0	30.9	30.0	30.3	30.5	31.2	31.0	30.7	30.9
	1998-2007	31.1	32.8	33.0	32.6	32.0	31.3	30.6	30.8	29.8	30.6	31.0	31.3	31.4
Tmin (°C)	2008	21.2	21.1	22.7	22.8	23.9	24.0	24.0	24.0	23.5	21.8	21.7	21.5	22.7
	1998-2007	21.5	21.7	22.2	23.6	24.3	23.8	24.0	23.8	24.0	22.8	22.3	21.7	22.9
Sunshine (hrs)	2008	6.7	7.6	3.7	4.4	6.4	5.9	6.9	5.9	5.9	5.9	5.5	7.0	6.0
	1998-2007	2.1	8.5	8.1	7.2	6.7	6.8	6.9	7.4	7.4	6.2	5.2	6.8	7.0
Evap. (mm)	2008	3.7	3.6	2.7	2.6	3.6	3.0	3.2	3.7	3.7	2.6	3.3	3.7	3.3
	1998-2007	4.1	4.4	4.3	4.2	3.7	3.7	4.0	3.9	3.8	3.0	3.2	3.7	3.8
RHam (%)	2008	85	86	89	86	84	86	85	84	82	85	86	85	85
	1998-2007	84	81	84	85	83	83	83	82	86	85	85	86	83
RHpm (%)	2008	77	82	85	82	84	84	83	83	80	82	82	79	82
	1998-2007	73	71	70	75	79	80	78	77	77	79	80	75	76

Table 13. ***Monthly climate variables in Ratmalagara (RE) Research Centre in 2008 and 10-year average***

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2008	51.6	73.4	248.1	294.0	62.8	65.7	118.1	72.6	51.6	754.1	266.7	34.3	2093.0
	1998-2007	60.8	39.6	95.3	178.0	180.2	106.3	45.3	53.4	108.5	395.1	320.3	110.7	1694.1
Tmax (°C)	2007	31.1	32.8	32.3	32.2	31.6	31.3	31.1	31.0	31.4	32.1	31.8	31.1	31.6
	1998-2007	31.7	33.5	34.2	33.1	32.2	31.2	30.9	31.5	31.9	30.9	31.4	31.0	31.9
Tmin (°C)	2008	21.4	21.8	22.9	23.2	24.9	24.5	24.1	24.0	23.4	22.6	22.4	21.4	23.0
	1998-2007	21.6	22.3	23.2	24.1	25.2	25.1	24.9	24.7	24.3	23.8	23.1	22.0	23.7
Sunshine (hrs)	2008	6.0	6.3	6.1	6.4	7.4	6.2	6.2	6.2	7.2	5.7	4.8	5.8	6.2
	1998-2007	4.7	6.4	6.6	6.2	5.6	5.2	5.1	5.9	5.6	5.1	5.1	5.2	5.6
Evap.(mm)	2008	2.5	2.9	2.5	2.4	2.9	2.3	2.7	2.7	2.8	2.9	1.9	2.2	2.6
	1998-2007	2.8	3.4	3.6	3.8	3.4	3.2	3.0	2.9	3.0	2.8	2.5	2.6	3.1
RHam (%)	2008	88	86	89	87	84	83	82	85	82	86	90	89	86
	1998-2007	88	87	88	86	83	83	80	80	81	85	88	88	85
RHpm (%)	2008	64	60	68	71	74	75	72	73	70	68	72	72	70
	1998-2007	67	60	64	70	75	76	74	71	70	75	76	71	71

Table 14. *Monthly climate variables in Ambakelle (ISG) Genetic Resource Centre in 2008 and 10-year average*

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2008	76.0	95.7	357.4	167.8	15.9	41.4	107.3	55.7	38.1	456.2	169.2	31.7	1608.4
	1998-2007	48.7	54.1	83.1	167.5	164.9	67.9	45.0	30.8	95.9	321.4	226.8	122.8	1429.0
Tmax (^{0}C)	2008	28.6	30.6	30.3	31.0	32.2	31.7	31.1	31.8	32.0	32.0	31.3	30.6	31.1
	1998-2007	31.1	32.8	33.5	33.1	32.5	31.3	31.2	31.6	31.9	31.0	30.9	31.6	31.8
Tmin (^{0}C)	2008	21.7	22.4	23.2	23.9	25.1	24.8	24.0	23.8	23.1	22.5	22.4	21.3	23.2
	1998-2007	21.9	21.9	23.0	24.0	25.1	25.2	24.9	24.8	24.4	23.7	23.0	22.5	23.7
Evap. (mm)	2008		2.8	2.9	2.8	2.8	2.7	2.9	2.8	3.0	3.0	2.3	2.5	2.8
	1998-2007	2.9	3.5	3.8	3.1	3.2	3.1	3.5	3.7	3.4	3.6	4.6	3.4	3.5
RHam (%)	2008	89	85	87	83	81	79	81	83	79	82	84	85	83
	1998-2007	86	84	82	83	84	83	82	80	80	84	85	85	83
RHpm (%)	2008	74	66	71	75	74	73	73	71	69	73	73	73	72
	1998-2007	69	66	67	75	77	77	81	75	71	70	72	79	73

Table 15. *Monthly climate variables in Maduru Oya (MO) Genetic Resource Centre in 2008 and 10-year average*

Variable	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
RF (mm)	2008	197.8	104.4	235.7	41.6	5.0	36.8	20.1	244.3	25.7	116.5	357.8	296.9	1682.6
	1998-2007	264.8	136.6	42.3	113.9	56.4	16.3	49.1	47.2	63.3	2.6.1	349.2	367.4	1712.6
Tmax (^{0}C)	2008	30.4	31.4	31.5	33.8	35.8	34.3	34.5	34.9	34.9	32.9	31.7	30.4	33.0
	1998-2007	30.2	31.7	34.1	34.8	35.2	35.2	34.8	35.1	35.4	33.7	30.9	30.6	33.5
Tmin (^{0}C)	2008	21.5	21.7	20.6	22.5	24.3	24.6	24.1	23.2	23.4	23.4	23.5	22.0	22.9
	1998-2007	20.9	20.6	20.6	21.8	20.5	22.8	23.1	22.5	22.4	22.2	22.3	21.6	21.8
SS (hrs)	2008	4.9	4.9	4.2	4.7	5.5	5.4	5.1	5.6	5.2	5.1	5.3	4.8	5.1
	1998-2007	5.3	6.2	7.9	6.7	6.5	6.8	7.9	7.4	7.1	6.1	4.9	4.9	6.5
Evap. (mm)	2008	4.4	3.7	4.2	4.7	5.1	5.2	5.2	4.9	5.1	5.4	5.4	5.0	4.9
	1998-2007	3.23	3.5	4.1	43	4.6	5.2	5.6	5.2	5.3	5.2	3.7	4.1	4.5
RHam (%)	2008	92	88	86	84	70	66	70	76	72	83	87	88	80
	1998-2007	76	71	63	68	62	58	50	61	58	65	75	75	66
RHpm (%)	2008	72	66	71	66	55	57	56	64	54	69	70	76	65
	1998-2007	61	67	61	66	61	58	57	55	56	64	75	76	63

Table 16. ***Monthly rainfall of the research centers at Poththukulama (PRS), Walpita and Pallama in 2008 and ten year average***

Location	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PRS	2008	74.9	66.5	357.0	173.7	10.7	115.9	114.5	60.2	39.2	424.5	186.1	53.9	1677.1
	1998-2007	41.8	38.2	106.9	182.3	117.7	66.4	43.7	33.8	81.4	317.5	232.4	114.6	1376.7
Walpita	2008	21.2	200.5	410.5	378.4	291.3	224.5	205.3	100.6	72.3	674.8	329.0	48.3	2956.7
	1998-2007	87.6	66.1	107.1	270.6	231.2	173.3	111.3	132.7	225.3	445.4	314.3	93.7	2258.6
Pallama	2008	118.0	51.6	345.7	287.8	10.5	81.5	130.0	59.5	10.0	471.0	165.4	50.0	1781.0
	2001-2007	43.1	24.8	81.3	222.3	126.1	81.7	52.6	20.4	72.3	331.6	266.6	109.9	1432.7

REPORT OF THE TISSUE CULTURE DIVISION

Head - L K Weerakoon, Ph D

1. SUMMARY

During the year, much emphasis was placed on culture of unfertilized ovaries which were shown to be the most promising explants for clonal propagation of coconut.

A total of 347 Dikiri embryos were cultured during the year and 165 *in vitro*-raised plants were transferred to soil for acclimatization. Hundred and forty dikiri plants were sold to growers. Sixty embryo-cultured dikiri plants established at Middeniya Research Center were found to be in good condition.

From previous results, it is clear that the current conditions applied for germplasm exchange need to be improved to achieve maximum possible success from recovery of embryos to field establishment of exotic plants. Thus studies aimed at optimizing the conditions for embryo transport and in vitro culture were undertaken. The embryos excised from mature nuts of the 2 varieties, Sri Lanka Tall and Cameroon Red Dwarf (CRD; exotic variety) were used as experimental material. The embryos were initially cultured and stored in 3 different storage media (sterile water, solidified agar and 1/4 strength Y3 solid medium) for 6 weeks, prior to transferring in to 2 different growth media, based on 2 different embryo culture protocols (standard embryo culture protocol practiced at CRI and a hybrid protocol). Preliminary results indicated that germination of CRD embryos that were stored in sterile water was poor whereas germination of those that were stored in the other 2 media was comparable to the control (embryos cultured directly without any storage). Even though storage in sterile water did not have a negative effect on embryo germination of the Tall variety, the germination rate could be improved further by storing the embryos in the other 2 media.

Promising results were obtained from some plumule cultures and these plumules were obtained from several tissue-cultured coconut palms of a single clone. Over 250 plantlets were regenerated from callus derived from these plumules. Sixteen of these plants are ready for field planting whereas 57 of them are at different stages of acclimatization. The rest of the plantlets are still growing in culture. Multiplication of embryogenic callus and induction of secondary somatic embryogenesis were two noteworthy achievements in plumule culture.

As a novel approach, studies on the effect of arabinogalactan proteins (AGPs) on coconut somatic embryogenesis were commenced. AGPs are extra cellular proteins involved in differentiation and embryogenesis. Based on literature, it can be assumed that AGPs have a potential to improve in vitro culture response of highly recalcitrant species such as coconut. Arabic gum was used as the main source of AGP and plumules and immature anthers were used as explants. In regard to plumules, a significant increase in the mass of embryogenic structures formed per embryogenic callus clump was observed with 10 mg l^{-1} Arabic gum. Even though some alternate sources of AGPs (1 % conditioned medium, in which tissues were cultured for some time, 250-500 mg l^{-1} carrot seed extract, 50-100 mg l^{-1} defatted coconut kernel and 50-100 mg l^{-1} commercial grade Arabic gum) were also tested, none of them had a significant effect on somatic embryogenesis. In regard to immature anthers, Arabic gum had an inhibitory effect on formation of callus-like structures whereas some of the alternate AGP sources promoted their formation.

In another investigation, immature anthers were co-cultured with different coconut explants such as plumules, immature zygotic embryos and unfertilized ovaries, to test the effect of any growth promoting substances released by them. According to preliminary results, a significant increase in the formation of callus-like structures was observed in immature anthers, co-cultured with unfertilized ovaries.

In general, growth of tissue-cultured coconut plants is slow. Thus different levels GA_3 and sucrose were applied (for 2 months) as an attempt to improve in vitro growth of some slow-growing coconut shoots. However, none of the treatments were effective in promoting shoot growth. Further, coconut shoots were maintained under natural light and culture room conditions for 2 months and their growth and biochemical parameters were determined afterwards. The results indicated the possibility of using natural light for coconut *in vitro* culture.

With the assistance of breeders, a group of elite palms were selected to collect ovary explants. Since tissue culture response is highly genotype dependent, the most responsive palms among the group will be selected. Ovary explants collected from 54 of the selected palms have already been cultured in callus induction medium. Callus initiation could be observed in ovaries collected from some of the palms.

Much emphasis was placed on improving the anther culture protocol. Several experiments were focused on reducing vitrification, a major constraint that limits the regeneration efficiency of anther-derived embryos. Application of high level of phytagel (0.5%) was shown to be effective in reducing vitrification by 50 %. The optimum duration of high phytagel treatment was also determined. It was revealed that selective sub-culturing of opaque embryos (over translucent embryos) into somatic embryo maturation medium could significantly lower the vitrification rate. The concentration of BAP and GA_3 was optimized to achieve a higher plant regeneration frequency. The formation of multiple shoots was observed to be higher than that of single shoots. However, the growth of the plantlets originating from multiple shoots was found to be poor. Histological studies revealed that multiple shoot initiation occur after sub-culturing the embryos into somatic embryo maturation medium. Thus attempts are underway to induce single shoots at an early stage.
The effect of coconut water on androgenesis induction and plant regeneration was studied and the results indicated that tender coconut water enhanced both the processes. The quality of the regenerated plants could also be improved by supplementing the maturation and germination media with coconut water.
Studies were initiated to test the feasibility of using anther – derived, non-embryogenic, fast growing calli (FGC) for plant regeneration. Induction of embryogenesis in FGC could be attained by applying a heat shock at 38 °C for 3 or 7 days.

Micropropagation of banana (cultivars 'Nethrampalam' and 'Agawiyaru") and pineapple was continued successfully. The field performance of tissue-cultured banana plants was highly satisfactory. Three hundred and forty one tissue-cultured banana plants were sold to growers at a nominal rate. Culture of 2 more varieties of banana, namely 'Suwandel' and 'Seeni kesel' was also initiated. Over 500 *in vitro*-raised pineapple plants were successfully acclimatized and 150 plants have already been established in the field. Their growth was found to be highly satisfactory.

Several ornamental plants were successfully micropropagated through tissue culture. The first set of tissue-cultured plants of *Dieffenbachia* ('Tropic snow') and *Cordyline terminalis* ('Count Dracula') were sold to the stake holder. The in vitro plant regeneration protocol of *Quisqualis indica* (double petal) was perfected and mass propagation of it is underway.

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 347 Dikiri embryos were cultured during the year and 165 *in vitro*-raised plants were transferred to soil for acclimatization. Hundred and forty dikiri plants were sold to growers. The performance of the 60 embryo-cultured dikiri plants established at Middeniya Research Center was found to be good. Out of the 73 Dikiri plants established at Bandirippuwa Estate, 57 are at bearing stage. It is no longer possible to collect dikiri nuts from Weligama area due to the prevailing leaf wilt disease. Thus the number of dikiri plants raised during the year was reduced.

L K Weerakoon, T R Gunathilake, K P I E Ambagala and E S Santha

Experiment 18.1.7: Exchange of coconut germplasm through embryo culture (2002)

From previous results, it is clear that the current conditions applied for germplasm exchange need to be improved to achieve maximum possible success from recovery of embryos to field establishment of exotic plants. Thus studies aimed at optimizing the conditions for embryo transport and in vitro culture were undertaken. The embryos excised from mature nuts of the 2 varieties, Sri Lanka Tall and Cameroon Red Dwarf (CRD; an exotic variety) were used as experimental material. The embryos were initially cultured and stored in 3 different media (sterile water, solidified agar and 1/4 strength Y3 solid medium) for 6 weeks, prior to transferring to 2 different growth media, based on 2 different embryo culture protocols (standard embryo culture protocol practiced at CRI and a hybrid protocol). The embryo germination and subsequent plant development in different treatments are summarized in Table 1.

Table 1: ***Embryo germination and plant development after storage in different media***

Treatment	CRD				Sri Lanka Tall			
	Standard		Hybrid		Standard		Hybrid	
	Germination (%)	Plant development (%)	Germination (%)	Plant development (%)	Germination (%)	Plant development (%)	Germination (%)	Plant development (%)
Control	43.4	30.0	-	-	66.7	55.6	-	-
(without storage)	57.1	57.1	66.7	53.3	60.0	46.7	93.3	93.3
Sterile water	11.7	5.9	-	-	63.6	45.5	-	-
1/4 strength Y3	41.7	50.0	-	-	73.3	69.2	-	-
	28.6	28.6	40.0	6.7	28.5	28.5	13.3	6.7
Solidified agar	46.7	54.5			75.0	72.7		-
	40.0	26.7	6.7	6.7	21.4		64.3	

The preliminary results revealed that transport of embryos in sterile water is an effective method for the variety Sri Lanka Tall. The success rate can be further improved by transporting embryos either in 1/4 strength Y3 medium or in solidified agar. In regard to CRD, sterile water is not suitable as a storage medium. Embryo germination and plant development in 1/4 strength Y3 and solidified agar were comparable to the control (embryos cultured directly without any storage) and thus can be considered as suitable storage media for this particular variety. In the control treatments (of both Sri Lanka Tall and CRD), the hybrid protocol was shown to be better

for embryo germination and this effect was significant for Sri Lanka Tall variety. However, this effect was not reflected when embryos were cultured after storage. Therefore, the experiment needs to be repeated to confirm the results.

S C Fernando, E S Santha and L K Weerakoon

18.2. Studies on clonal propagation of coconut

Experiment 18. 2. 4. Culture of floral meristem explants (1995)

Immature anther could be another potential explant for clonal propagation and it can be collected in large numbers from elite palms. It's response to *in vitro* culture has been tested in a few experiments without any success. Arabinogalactan proteins (AGPs) are extra cellular proteins involved in differentiation and embryogenesis. AGPs have been used successfully to induce *in vitro* responsiveness of non-responsive anthers and other tissues of several plant species. Thus the effect of AGPs on *in vitro* culture response of coconut immature anthers was studied.

Immature anthers collected from immature inflorescences of -4 development stage were cultured in basal medium CRI 72 supplemented with 2,4-D alone or in combination with TDZ. The media were supplemented with different sources of AGPs (0-50 mg l^{-1}Arabic gum,. 1 % conditioned medium [CM] [culture medium in which tissues were cultured for some time], 250-500 mg l^{-1} carrot seed extract [CS], 50-100 mg l^{-1} defatted coconut kernel [DCK] and 50 100 mg l^{-1} commercial grade Arabic gum [CAG]).

Initiation of callus-like structures from cultured immature anthers was observed in some of the treatments. The frequency of formation of these structures depended on the genotype, culture medium and AGPs present in the medium. Supplementing the culture medium with a combination of 2,4-D and TDZ was found to be more effective than
2,4-D alone. Arabic gum brought about an inhibitory effect whereas the other AGP sources (except carrot seed extract) showed an improvement over the control. Formation of callus-like structures could be significantly improved with the use of conditioned medium.

In another investigation, immature anthers were co-cultured with different coconut explants such as plumules, immature zygotic embryos and unfertilized ovaries, to test the effect of any growth promoting substances released by them. According to preliminary results, a significant increase in the formation of callus-like structures was observed in immature anthers, co-cultured with unfertilized ovaries.

S C Fernando and V Vidhanaarachchi

Experiment 18. 2. 5. Culture of plumule explants (1997)

The genotype effect on the in vitro response was clearly exhibited by some of the results obtained. Callus derived from a few plumules obtained from several tissue-cultured coconut palms (of a single clone) produced over 250 plantlets, indicating the higher regeneration potential of palms of this particular clone. Sixteen of these plants are ready for field planting whereas 57 of them are at different stages of acclimatization. The rest of the plantlets are still growing in culture. It was noted that the shoot growth of plants that are produced in clusters is generally poor.

The effect of conditioned media on somatic embryogenesis and shoot regeneration was tested by using 5% (v/v) liquid extract of a used anther culture medium. According to preliminary results, the conditioned medium not only promoted shoot regeneration but also induced secondary embryogenesis in some of the cultures. This result is encouraging and experiments are underway to study this further.

As a novel approach, studies on the effect of AGPs on coconut somatic embryogenesis were commenced. There is compelling evidence to show that AGPs promote somatic embryogenesis in several plant species. The type and quantity of AGPs is cell-specific and the presence of a specific AGP in a specific quantity seems to be essential for successful somatic embryogenesis. Based on literature, it can be assumed that AGPs have a potential to improve in vitro culture response of highly recalcitrant species such as coconut, even though their role has not yet been studied in any palm species. Therefore, initial studies were undertaken to test the effect of AGPs on coconut somatic embryogenesis.

Arabic gum was used as the main source of AGP. The effect of Arabic gum on callogenesis and early somatic embryogenesis was tested by culturing plumules or plumule-derived calli in media supplemented with different concentrations (0, 1, 10 and 50 mg l^{-1}) of Arabic gum. Application of Arabic gum did not have any effect on callus initiation in cultured plumules. Further, incorporation of Arabic gum in to somatic embryogenesis induction medium did not significantly increase the frequency of embryogenic cultures. However, with Arabic gum at 10 mg l^{-1} , a significant increase in the mass of embryogenic structures formed per embryogenic callus clump was observed (Table 2).

Table 2: ***Effect of Arabic gum on induction of callogenesis and early somatic embryogenesis***

Level of Arabic gum (mg l^{-1})	**Cultures with embryogenic structures (%)**	**Embryogenic structures per embryogenic callus clump (g)**
0	76	0.027 [b]
1	80	0.033 [b]
10	72	0.051 [a]
50	68	0.040 [ab]
Significance	NS	*

The effect of alternate sources of AGPs (1 % conditioned medium [CM] [culture medium in which tissues were cultured for some time], 250-500 mg l^{-1} carrot seed extract [CS], 50-100 mg l^{-1} defatted coconut kernel [DCK] and 50-100 mg l^{-1} commercial grade Arabic gum [CAG]) on somatic embryogenesis was also tested. In the case of CS, all the cultures showed severe necrosis indicating that the selected levels of CS were too high. The other sources tested did not have any significant effect on formation of embryogenic cultures or mass of embryogenic structures formed per embryogenic callus clump (Table 3).

Table 3. ***Effect of alternate sources of AGPs on somatic embryogenesis***

AGP source	**Cultures with embryogenic structures (%)**	**Embryogenic structures per embryogenic callus clump (g)**
Control (without AGP)	40	0.020
CM	55	0.022
DCK 50	60	0.023
DCK 100	50	0.021
CAG 50	65	0.021
CAG 100	60	0.022
Significance	NS	NS

Further experiments are in progress to assess the effect of AGPs on later stages of somatic embryogenesis and the presence of AGPs in different regeneration protocols.

The in vitro growth of coconut plantlets is generally slow. Thus, they need to be maintained under in vitro conditions for a long period which is laborious and costly. A study was undertaken as an attempt to improve the growth of some plumule-derived, slow-growing coconut shoots. The effect of 2-month application of different levels of GA_3 (0, 0.4 and 0.6 µM) and sucrose (4 and 6 %) on their growth was studied. According to the results, both GA_3 (Table 4) and sucrose treatments did not have any significant effect on shoot growth. The treatments were applied for only 2 months and the duration of application might not be adequate to bring about any response in the treated shoots.

Table 4: ***Effect of different levels of GA_3 on growth of coconut shoots***

GA_3 concentration (µM)	Plant height (cm)	Rate of new leaf production (leaf/plant/month)
0.0	3.8	0.5
0.4	4.9	0.7
0.6	4.1	0.6
Significance	NS	NS

The available nutrients in the used-up culture media were analyzed to determine whether the slow growth of plantlets is due to insufficient nutrients. Analysis of nitrogen and phosphorous did not show any limitation. The amounts of other nutrients such as K, Ca, Mg, Na and micro nutrients were highly variable among the replicates. Thus, the results were inconclusive.

S C Fernando, V Vidhanaarachchi and E S Santha

Experiment 18. 2. 6. Culture of unfertilized ovary explants (1997)

With the assistance of breeders, a group of elite palms were selected to collect ovary explants. Since tissue culture response is highly genotype dependent, the most responsive palms among the group will be selected.

The *in vitro* response of unfertilized-ovaries collected from 12 D X T hybrid palms (about 40 years of age) and 15 Sri Lanka Tall palms (about 25 years of age) were assessed by culturing them in basal medium CRI 72 supplemented with 100 µM 2,4-D, 9 µM TDZ and 0.1% BDH charcoal for more than 3 months. As shown in Table 5, both the percentage of palms producing callus and callusing frequency were higher in Tall palms when compared to the hybrid.

Table 5. ***Callogenesis in unfertilized-ovaries collected from palms of 2 different varieties***

Variety	No. of palms tested	Palms producing callus (%)	Callusing frequency (%)
DXT	12	54.5	3.3 – 16.7
Sri Lanka Tall	15	66.7	5.6 – 50.0

Further, a higher proportion of the ovary-derived callus of D X T palms was smaller in size and of poor quality. This could be attributed to the difference in genotype and physiological maturity of the mother palms. Experiments are in progress to improve callus initiation and multiplication. Furthermore, ovary cultures of 28 more palms were initiated recently to assess their in vitro culture response.

V Vidhanaarachchi, S C Fernando and E S Santha

Experiment 18. 2. 7. Studies on anther and microspore culture (1997)

High vitrification of the anther-derived structures is a major constraint that limits the regeneration efficiency. Therefore much emphasis was placed on reducing the occurrence of vitrification. Based on morphological aspects, two types of anther-derived structures (translucent and opaque) were identified. As shown in Table 6, selective sub-culturing of the opaque embryos (over translucent embryos) into somatic embryo maturation medium (hormone free medium) significantly lowered the vitrification rate (G^2=6.73; $p<0.01$). However, selection of embryos at an early stage is tedious and thus increasing the concentration of solidifying agent in the culture medium was tested as an alternative measure to reduce vitrification.

Table 6. ***Effect of selective subculturing of anther-derived embryos on vitrification***

Type of the embryo cultured	Total number of embryos cultured	Percentage of vitrification
Translucent embryos	41	39.0
Opaque embryos	49	14.1
MLAOV		**Significant**

In this experiment, the effect of incorporating a higher level of phytagel (0.4%) into the embryo maturation medium was tested against the control (normal level of 0.25%). The results clearly indicated that high level of phytagel was effective in reducing vitrification by about 50% (Table 2. G^2=7.82; $p<0.01$).

Table 7. ***Effect of phytagel concentration on vitrification***

Concentration of phytagel	Total number of embryos cultured	Percentage of vitrification
0.25%	**112**	**34.8**
0.4%	**80**	**16.3**
MLAOV		**significant**

Another experiment was conducted to study the effect of duration of exposure to high phytagel. The results indicated that longer exposure to high phytagel (0.4 %) could reduce vitrification (Table 8). Vitrification could be reduced by about 40% with the exposure of embryos to high phytagel for 21 days (Table 3. G^2=13.88; $p<0.001$).

A preliminary study was conducted to study the effect of coconut water on androgenesis induction and plant regeneration. According to the results, enhancement of androgenesis induction and plant regeneration was higher with tender coconut water when compared to coconut water obtained from mature nuts and already germinated nuts. Further, the quality of regenerated plants was improved by applying coconut water to maturation and germination media.

Preliminary studies indicated that the level of BAP (5 µM) currently applied to the culture medium is not sufficient for the germination and subsequent development of germinated embryo.

Table 8. ***Effect of different durations of exposure to high phytagel on embryo vitrification, germination and formation of single/double shoots***

Duration of exposure to high phytagel (days)	Total number of embryos tested	Percentage of vitrification	Percentage of embryo germination	Formation of single/double shoots
0 (control)(T1)	38	65.8	7.9	0
3 (T2)	41	51.2	12.2	40
7 (T3)	42	40.5	16.7	100
14 (T4)	40	40.0	17.5	71.4
21 (T5)	46	23.9	21.7	70
MLAOV		15.21**	NS	NS
Significant contrasts		T1 vs T3 (5.01*) T1 vs T4 (5.08*) T1 vs T5 (13.88***)		

Thus a range of concentrations (5 [control], 15, 25, 35, 45, 55 µM) was tested to determine the optimum level of BAP in the embryo germination medium. The highest rate of conversion and shoot development was observed with 25 µM BAP (Fig.1).

Studies were also undertaken to optimize the GA_3 concentration in the germination medium. Four levels of GA_3 (0.75, 1.0, 1.5, 2.0 µM) were compared with the control (0.45 µM).

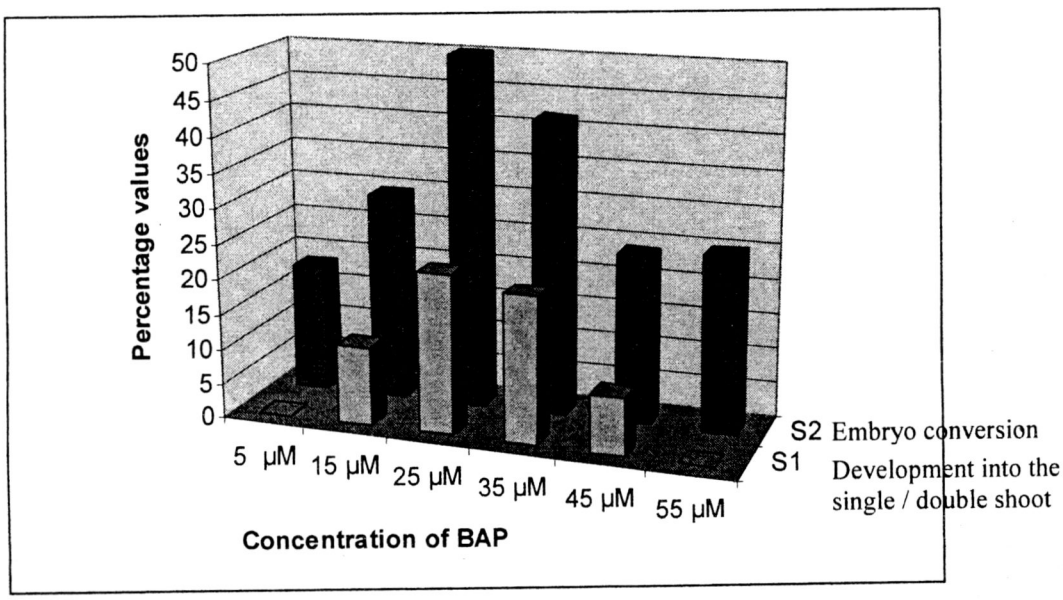


Fig 1. ***Effect of BAP concentration in the germination medium on embryo conversion and shoot development.***

Even though the effect of GA_3 on embryo conversion was not significant, the formation of single/ double shoot was significantly higher with higher concentrations of GA_3 (Fig. 2).

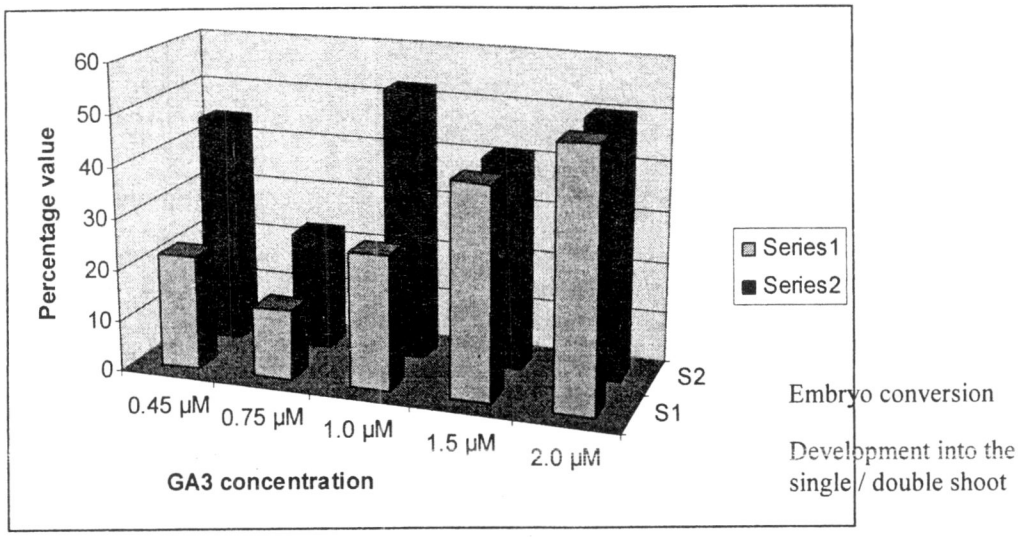


Fig.2. ***Effect of GA3 concentration in the germination medium on embryo conversion and shoot development.***

Histological studies were conducted to study the formation and development of embryos, organization of the anther-derived fast growing calli and the phenomenon of vitrification, at cellular level. Embryogenic structures were categorized into four groups based on their morphological characters. The type of the structure and the total number of structures analyzed in each category are given in Table 9.

Table 9. ***The type and number of anther-derived structures used for histological analysis***

Type of structure	**Number**
Blunt embryos	38
Germinated embryos and embryos with germination point	26
Vitrified Embryos	15
Fast Growing Calli	03

The embryos without a shoot or a visible germination point were termed as blunt embryos. However, in rare cases, the root pole was present. According to the preliminary observations, majority of the blunt embryos did not germinate even after three or four subcultures to the germination medium. Further, their regeneration potential could not be assessed by any morphological features. By analyzing their cellular organization, the appropriate duration of maintaining them in culture could be determined.

A total of 38 blunt embryos were analyzed histologically to examine their germination potential (Table 9). Four types of embryos could be identified based on the presence of root or shoot meristem within the haustorium (Table 10). Only 8 % of the embryos had bipolar arrangement indicating that they are complete embryos which have the capacity to develop into complete plantlets. The embryos having either the shoot or the root meristem were incomplete embryos. As shown in table 10, the majority of the incomplete embryos contained only the root meristem (31 %) whereas 13 % contained only the shoot meristem. Nearly half (47%) of the embryos analyzed did not contain either the root or the shoot pole. Since 13 % of the blunt embryos contained the shoot meristem, discarding all of them at early stages of development should not be done. Formation of blunt embryos may be attributed to the time that the embryogenic structures were exposed to cytokinins. Furthermore, the genotype of the pollen grain could also affect proper development of the embryo.

Table 10. ***Frequency of occurrence of different types of blunt embryos***

Type of blunt embryo	Frequency of occurrence
Complete bipolar embryo	8 %
Embryos with only shoot meristem	13 %
Embryos with only root meristem	31%
Embryos without either root or shoot meristem	47 %

The embryos containing a depression on the surface were categorized as the embryos with a germination point and they have a high tendency to germinate. However, in rare cases, the shoot development was not observed. The present study clearly revealed the cellular arrangement at the germination point. The cells differentiating into the shoot meristem have a high nucleus to cytoplasm ratio, indicating their high meristematic activity. However, the surrounding parenchyma cells in the haustorium had a low nucleus to cytoplasm ratio. Due to this differential cell division in the haustorium, a depression is created on the surface of the embryo. The developing shoot meristem is emerged through the germination point.

Three types of shoot development namely, single, double and multiple could be observed in the germinated embryos. During early stages of germination, these cannot be differentiated based on their morphological features. Furthermore, some fused shoots were also present at a very low frequency.

Vitrification of ungerminated as well as germinated embryos occurs both in maturation medium and germination medium and it leads to loss of regeneration potential of these embryos. Histological observations revealed that the cells in the central part of the vitrified tissue are damaged, creating a hole. Vitification extends from the bottom to top of the structure. While the cells of the non-vitrified part of the tissue divide normally, the vitrified cells are damaged causing cracking of the central/ basal part of the structure. This is the reason for the presence of a central hole in some of the vitrified structures. If vitrification has not extended up to the shoot point of the germinated embryo, isolated shoot tissue can be induced to re-enter the regeneration cycle either by shoot tip culture or induction of callogenesis. The exact reason for the occurrence of vitrification is not yet clear. The genotype of the pollen grain and culture medium may influence the incidence of vitrification.

Friable calli with very high multiplication rate was formed in the cultured anthers at a frequency of 1% and they were termed as fast growing calli (FGC). Their origin is not clear and the embryogenic potential of these structures have not been studied. Plant regeneration efficiency could be enhanced if there is a possibility of converting FGC into embryogenic structures. Histological analysis of FGC revealed that there were isolated active cell clumps that were comparable to the multicellular pro-embryos derived from cultured anthers. Nucleus to cytoplasm ratio of these cells was high indicating meristematic activity. Under appropriate conditions, these pro-embryo-like structures could give rise to direct embryos and this would result in a significant increase in the regeneration frequency.

Based on the histological studies, experiments were initiated to test the feasibility of using anther–derived, FGC for plant regeneration. Intact FGC produced in androgenesis induction medium were subjected to heat pre-treatment at 38 °C for different durations
(1 hr., 3hr., 7hr., 24hr., 48 hr, 3 days and 7 days) and cultured to the androgenesis induction medium supplemented with 50 µM 2,4-D. Embryogenesis induction in non-embryogenic FGC could be achieved by applying a heat shock at 38 °C for either 3 or 7 days.

P I P Perera

Experiment 18. 2. 14. Micropropagation of high-value crops (2002)

Micropropagation of banana (cultivars 'Nethrampalam' and 'Agawiyaru") and pineapple was continued successfully. The field performance of tissue-cultured banana plants was highly satisfactory. Three hundred and forty one tissue-cultured banana plants were sold to growers at a nominal rate. Culture of 2 more varieties of banana, namely 'Suwandel' and 'Seeni kesel' was also initiated. Over 500 *in vitro*-raised pineapple plants were successfully acclimatized and 150 plants have already been established in the field. Their growth was found to be highly satisfactory.

Several ornamental plants were successfully micropropagated through tissue culture. The first set of tissue-cultured plants of *Dieffenbachia* ('Tropic snow') and *Cordyline terminalis* ('Count Dracula') were sold to the stake holder. The in vitro plant regeneration protocol of *Quisqualis indica* (double petal) was perfected and mass propagation of it is underway.

V Vidhanaarachchi, S C Fernando, L K Weerakoon, T R Gunathilake, E S Santha and K P I E Ambagala

3. ACKNOWLEDGMENTS

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REPORT OF THE COCONUT PROCESSING RESEARCH DIVISION

Officer –In –Charge - L.L.W.C. Yalegama

GENERAL

The research programme of the Coconut Processing Research Division focused mainly on improvement of processing technologies relevant to the coconut processing sector. Problems associated with copra processing, coconut milk processing, coconut oil processing, retting of coconut husks and development of coir based products were addressed. Fabrication of a heat recovery unit was also completed during the year.

A study was conducted to develop a method to accelerate the ball copra making process. Ball copra was prepared using modified copra kiln instead of the natural process. The results indicated that kiln drying can be used for making ball copra. However, quality was affected due to over heating. Therefore the method of drying should be improved.

It was observed that shelf life of copra is very short and it deteriorates very easily. Therefore a study was conducted to develop a packaging system to increase the shelf life of copra. The results indicated that packaging materials such as metalized polyester polyethylene (Met-Pet) and oriented poly propylene (OPP) can increase the quality of copra during storage. However, poly bags were found to be unsuitable for storing copra. Experiments carried out for increasing quality of paring oil indicated the quality of paring oil can be improved by improving the method of processing of coconut parings. Accelerated drying of parings can minimize the initial moisture and free fatty acid content of paring oil extracted.

A study was conducted to process coconut milk as pasteurized coconut milk pouch for domestic consumption. The processing parameters were studied. The processed product had a shelf life of 20 days under refrigerated conditions. The processing method is a manual method which is suitable for cottage industry.

Work on accelerating coconut husk retting process was continued in 2008. From a lab scale experiment, 21 days retted samples showed a higher tensile strength than the control which is obtained by traditional process. A pilot scale trial was initiated in Dunkannawa Research Center where inoculation of culture samples to 2000ft^3 water volumes were done in 7000 ft^3 tanks. The results indicated that the density of microbes were inadequate. Trials are underway to confirm the results.Several experiments are in progress to develop coir based products such as coir pots, turfs, weed mats and bags.

Development of machinery was also carried out during the year. Fabrication of a heat recovery unit for processing good quality charcoal and drying of coconut kernel was completed and installed. The trials will be carried out in 2009.

Experiment 01:- Preparation of ball copra from kiln drying.

At present, ball copra is made traditionally at domestic level mainly for medicinal purpose. It is also used for edible purposes in a limited quantity. Ball copra is produced in large scale in countries like India. It is produced by a natural process in which the nuts are kept in shade for about 11-12 months. The advantages of ball copra are the longer shelf life and less contamination as it is not exposed to the environment. It has a sweet taste when compared with smoked, cured

cup copra. Therefore a study was conducted to accelerate the formation of ball copra using a copra kiln.

Good quality seasoned coconuts (with husk) were obtained from Bandirippuwa estate and the nuts were processed using a modified copra kiln designed for making white copra.

Arrangement of Coconuts in the Copra Bed

The Experiment was arranged in Completely Randomized Block Design (RCBD) with three replicates. Drying compartment of the kiln divided into three blocks (front [block -01], middle [block-02] and rear end [block-03]). Randomly selected fifty coconuts were processed in each block. In each block, 30 nuts (randomly selected) were labeled for determination of weight loss. The fresh weights of the labeled nuts were measured and recorded separately before kiln drying. The nuts were arranged on pre-selected copra bed as a single layer. Charcoal powder was used as the fuel source for firing the kiln. Kiln drying with a number of firing cycles were continued up to the production of ball copra.

Temperature Distribution

The temperature of the drying platform (block-1, block-2 and block-3) was measured during drying by keeping 50 ml bottles containing water at different locations of the copra bed. The temperature was measured at three hour intervals during each firing cycle.

Weight Loss

The weights of the labeled nuts were taken after each firing cycle. Percentage of weight loss was calculated.

Ball Copra Formation

Complete evaporation of water and sound of shaking the kernel were taken as the indication of formation of ball copra. The formation of ball copra was observed after each firing and the number of ball copra formed was recorded.

Statistical Analysis

The data were statistically analyzed by ANOVA procedure using MINITAB statistical package at 0.05 probability level.

Temperature Distribution

There was a significant difference in temperature distribution ($P< 0.05$) among the blocks. The temperature in block -01 was significantly lower than in the block -02 and block-03. There was no significant different between blocks-02 and 03 (Fig.1.1). The temperature of block-01 was around 30°C - 35°C. During six firing cycles, 32.8°C, 48.8°C and 49°C of maximum average temperatures were observed in block-01, block-02 and block-03 respectively. This indicates that the temperature of the drying chamber was not consistent.

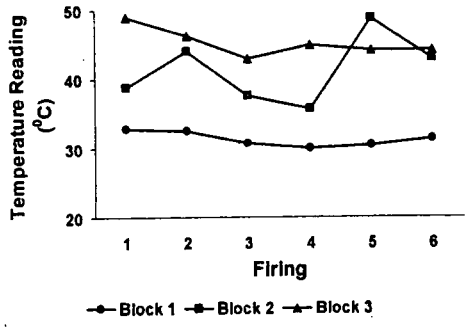

Fig1.1. ***Average temperature distribution of the copra bed***

Weight Loss

As shown in Figure 1.2, there was a significant effect of firing on weight loss ($p< 0.05$) during drying. There is a relationship between weight loss and temperature variation. Temperature of block-01 is below 35°C during firing and the lowest weight loss was also observed in block-01. The results showed that there was a relationship of the temperature of the drying chamber and the weight loss. However, there was no significant difference in loss of weight in block -02 and the blocks-03 (Figure 1.2). After 35th firing, 28.35%, 33.18% and 31.88% of average weight losses were observed in blocks -01, 02 and 03 respectively.

Depending on the variety, a matured coconut weights 3-4kg and is composed of about 35% husk, 12% shell, 22% meat and 25% water. On average, fresh coconut meat consists of 50% water. During ball copra formation, weight loss is due to the loss of moisture from the husk, nut water in the cavity and the meat. During weight loss, nut water is absorbed by the kernel and it enriches the meat. It was observed that the moisture removal was slower with increasing number of firing.

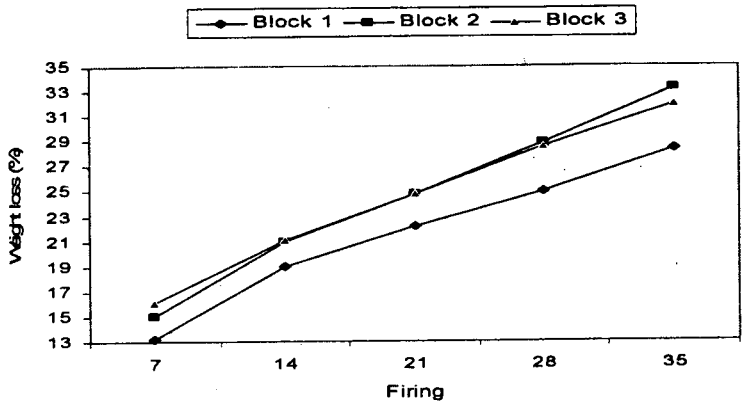

Figure 1.2. ***Average weight loss of coconut in different blocks during kiln drying.***

Ball copra formation

The results showed that there was a significant effect of firing on ball copra formation ($P < 0.05$). Ball copra formation was observed on 12th firing. Initial ball copra formation was two percent in block-03. The results showed an increasing trend of ball copra formation in each block (Figure1.3). After 35th firing, the percentages of ball copra formation were 94%, 78% and 44% in blocks 03, 02 and 01 respectively. Very low percentage of ball copra formation in block-01 was due to the exposure to the low temperature during drying.

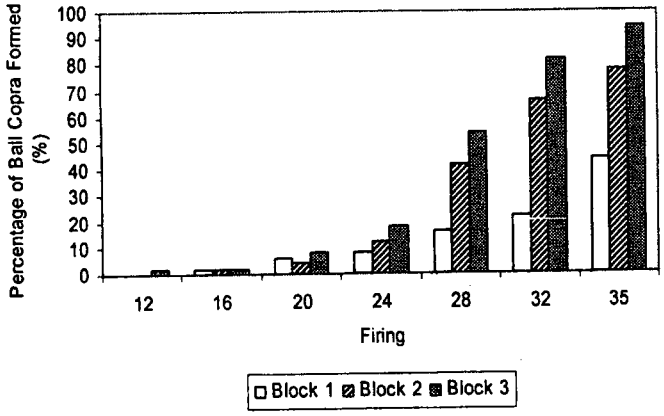

Figure 1.3. ***Percent distribution of ball copra formation***

The drying characteristics of copra are significantly affected by the drying temperature. However, the appearance of the kiln dried ball copra was not as good as the natural-cured ball copra. It showed an oily appearance and the moisture content also high. Therefore further studies are needed to improve the method of dying of ball copra.

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Experiment 2: A study on increasing the keeping quality of cup copra

Cup copra is mainly produced in copra kilns in Sri Lanka. The copra is stored at ambient conditions in open areas or in polybags until it is further processed for coconut oil or exporting. During storage contamination (microbial, chemical and physical) takes place which gives rise to poor quality copra. As this affects the income of the processors, there is a need to find out proper method of storing cup copra.

Thus a study was conducted with the objective of evaluating the effect of different packaging materials on the keeping quality of cup copra.

Samples from edible copra were packed using several packaging materials, namely vacuum packing in Low Density Polyethylene – LDPE, Oriented Polypropylene (OPP), Aluminium Laminated Polythene (Alu-Poly), metalized polyester (Met –Pet), Polysac and a control (without packaging) was also included.

Randomly selected, 3 cups of copra were placed in each packaging material (25cm x 20cm) and sealed properly. The samples were stored under ambient conditions. The samples from each treatment were analysed for its quality during storage. The moisture content, oil content, free fatty acid content (FFA) and appearance were determined according to the SLS 612:1983.

Appearance

As shown in Fig. 2.1. the appearance of the control and the samples packed in polysac was poor (the value is higher for inferior copra). The appearance of the samples packed in OPP and aluminum laminated polyethylene (Alu-poly) was average whereas vacuum packed samples and samples packed in met –pet showed a good appearance.

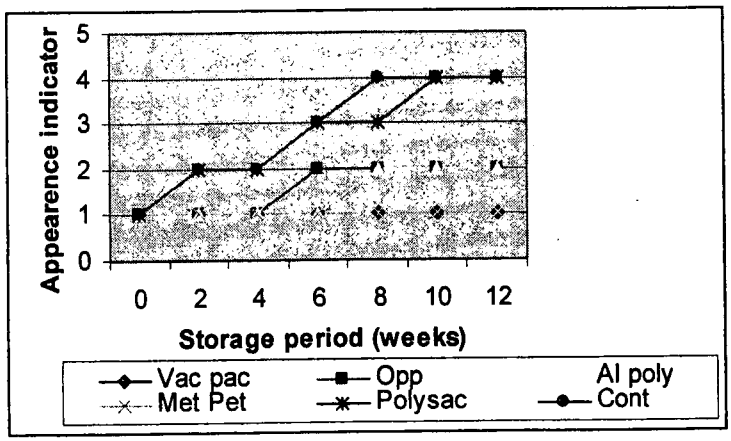

Fig. 2.1 ***Appearance of copra stored in different packaging materials***

Oil content

Oil content indicates the quality of copra. Good quality copra contains 65 -68% of oil. The oil content reduces when the quality is affected. The fig. 2.2 shows the oil content of copra packed in different packaging materials during storage.

The initial oil content is the same in all the treatments. But the oil content varies with time in treatments (Fig. 2.2). In the control and the samples packed in polysac, OPP and Alu-poly showed steady decrease during the storage. Met –pet and Vacuum packaging were found to be better packaging material when the change of oil content during storage is considered.

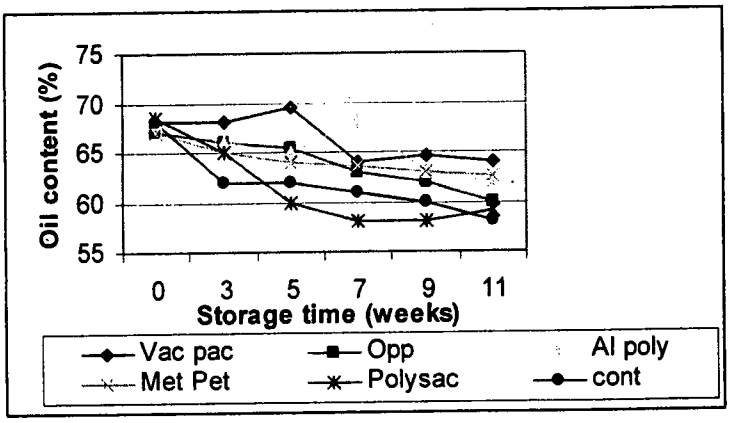

Figure 2.2. ***Variation of oil content of copra stored in different packaging materials***

Free fatty acid content

Free fatty acid (FFA) content is an indicator of the keeping quality of copra. The SLS standard for the FFA content of edible copra is less than 1%. The FFA content of the copra recorded at two week intervals are given in figure 2.3. The initial FFA values conformed to the SLS standard.

The results in figure 2.3 showed that the Free fatty acid contents of all the samples increased during storage. The initial FFA values of all the samples are the same and it conformed to the SLS standards of free fatty acids contents of copra. The copra packed in polysac and the control showed a steady increase of FFA values and it reached the critical level of FFA in less than 7 weeks. Samples packed in other packaging materials showed lower rates of increasing FFA levels. The samples packed in Al laminated polyethylene, Met- pet and vacuum packaging were stable up to 11 weeks.

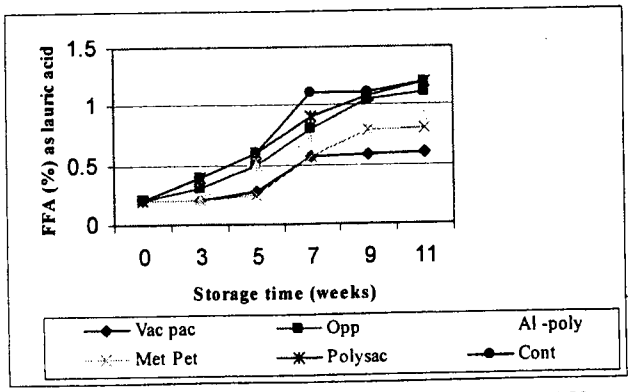

Fig.2.3 ***Variation of Free Fatty Acid content of copra stored in different packaging materials***

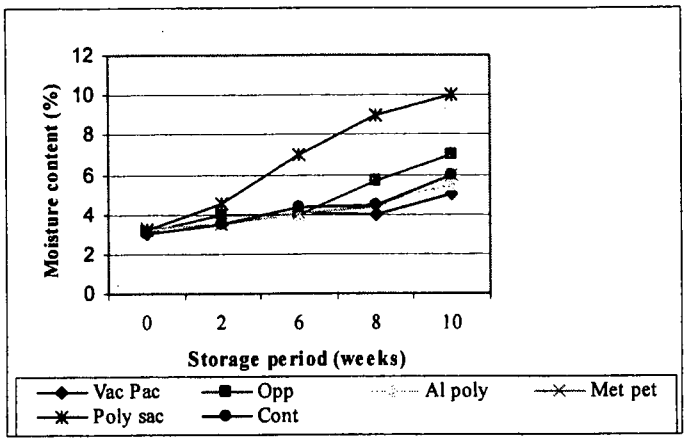

Fig 2.4 Change in moisture content of copra stored in different packaging materials

As shown in Fig.2.4, there was no significant difference among the initial moisture content of the samples. The moisture content of samples stored in poly sac increased steadily during storage. The results indicated that with the use of proper packaging materials the shelf life of copra can be improved.

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Experiment : 3 Development of ready to use pasteurized coconut milk

The milky fluid obtained by manual or mechanical extraction of fresh coconut kernel with or without addition of water is referred to as coconut milk.. It is a white, opaque protein-oil-water emulsion and free from fiber. The preparation of coconut milk is done manually as a household exercise. It is reported that Sri Lanka consumes 70% of its annual nut production for domestic use. Commercial production of coconut milk will help to reduce the wastage of nuts and effective utilization of by- products and thereby maximizing the income.

In order to find out the possibility of making pasteurized coconut milk with a relatively low investment and simple processing equipments, effective stabilizer for coconut milk processing, pasteurization temperature, suitable packaging material and storage time were studied.

Preparation of coconut milk pouch

Mature fresh nuts were de-husked and splitted manually. Then the split coconuts were washed with water containing 100 ppm H_2O_2 solution followed by potable water in order to practice sanitation. Then the coconuts were shredded manually (with a coconut scraper) without brown testa.

The shredded coconut was steam blanched for about 10 minutes to reduce the initial microbial load and milk was extracted using a hydraulic press without adding water. Then warm water was added to the extracted coconut milk to obtain 20% fat content and the milk was heated to 55°C using a water bath. Vitamin E was added as an antioxidant (200 mg/kg).Then the milk was homogenized at 11,000 rpm for 15 minutes using a homogenizer. While homogenizing the stabilizers were added. Then the milk sample was pasteurized in a water bath with stirring and packaging was done. Finally the pasteurized coconut milk was stored at 4°C.

Following experiments were carried out to determine the processing parameters of processed coconut milk.

Experiment 1

This experiment was carried out to select suitable stabilizers to prevent layer separation of coconut milk. Sterilized Jam bottles were used and shelf life was evaluated for three weeks. Samples were pasteurized at 72°C for 20 minutes. The treatments are given below.

Treatment 1 – 1 % Sodium Caseinate
Treatment 2 – 1 % Sodium Stearoryl Lactylate
Treatment 3 – 0.5 % Sodium Caseinate + 0.5 % Sodium Stearoryl Lactylate
Control – No stabilizers.

Experiment 2

This experiment was carried out to determine the correct time-temperature combination for pasteurization of coconut milk. Sterilized Jam bottles were used for storage and shelf life was evaluated for four weeks. The treatments are given below.

Treatment 1 – Pasteurization at 72°C for 10 minutes
Treatment 2 – Pasteurization at 72°C for 20 minutes
Treatment 3 – Pasteurization at 72°C for 30 minutes
Control – No Pasteurization

Experiment 3

This experiment was carried out to select a suitable packaging material for pasteurized coconut milk. Coconut milk was pasteurized at 72°C for 30 minutes and shelf life was evaluated for four weeks. 100 ml pouches were prepared using 2 types of materials namely; nylon polyethylene and aluminum laminated polyethylene.

Storage studies

- pH was measured using pH meter at 25°C in 2-3 days intervals.
- Brix value was measured using hand refractometer in 2-3 intervals.
- Taste, Odor, Color and Layer separation were checked organoleptically in 2-3 days intervals.
- FFA (Free Fatty Acids) contents were determined 2-3 days intervals (Pearson, 1993)
- Microbial plate count was determined according to the SLS: 516 (1991).

Sensory evaluation tests

Consumer preference test

A sensory evaluation test was carried out to test the acceptability of coconut milk stored for two weeks. Sago cooked with fresh and stored coconut milk (two weeks) was served to 33 untrained panelists for evaluation of taste, color, aroma and overall acceptability, using a 9-point hedonic scale where 9 refers to dislike extremely and 1 refers to like extremely. The test was carried out at University of Peradeniya.

Second sensory evaluation was carried out to test the acceptability of coconut milk stored for four weeks. Sago cooked with fresh and stored coconut milk was served to 22 untrained panelists at Coconut Research Institue, Lunuwila.

Shelf life evaluation.

Several batches of samples were stored in the refrigerator at 4°C and at room temperature and were observed for coagulation as well as development of sour taste and other off-flavors.

Statistical analysis

The sensory evaluation results were analyzed statistically using MINITAB 14. Balanced ANOVA was used at a 95% confidence level ($p < 0.05$). Total Plate Count was statistically

analyzed using SAS 6.12, where two-way ANOVA is used and Mean separation was done using Dunnett's method.

Coconut milk was extracted from fresh coconut meat using the hydraulic press machine. The efficiency of milk extraction and the fat content of each extracts are given in table 3.1.

Table 3.1: ***Efficiency of milk extraction***

	No. of nuts	Wt of scraped coconuts (g)	Wt of milk extracted (g)	Percentage yield of milk	Fat content %
	34	8672	4953.6	57.1	35.8
	26	6733	3806.6	56.6	35.0
	29	7234	4205.5	58.1	-
Average	30	7546	4321.9	57.3	35.4

According to the results in table 3.1, 57.3 % of coconut milk can be extracted from scraped coconut using hydraulic press. The fat content of coconut milk is 35.4%.This is referred to as coconut cream. The advantage of mechanical extraction of coconut milk is that efficient utilization of the by products obtained in the production process. The average fat content of house hold coconut milk is about 15% and desired fat content suitable for culinary purposes is 20% (Annual report 2007) . Therefore the coconut cream was further diluted by adding water (up to 50%) to make coconut milk pouch with 20% fat for direct consumption.

Suitable stabilizer for coconut milk

Different stabilizers, 1% sodium caseinate, 1% sodium stearoryl lactate, and 0.5% sodium caseinate and 0.5% sodium stearoryl lactate were added to the coconut milk while mixing at 55°C. Then the milk was pasteurized at 72°C for 20 minutes and stored under refrigerated conditions for 3 weeks. The initial pH of coconut milk is 6-6.3. The product did not show any variation until 17 days. After 17 days the product without any stabilizer and the 1% sodium caseinate added samples showed a drop in the pH value. These two samples showed pH below the range 5.9-6.3 after 17 days. Other samples were within the range of the pH of fresh coconut milk.

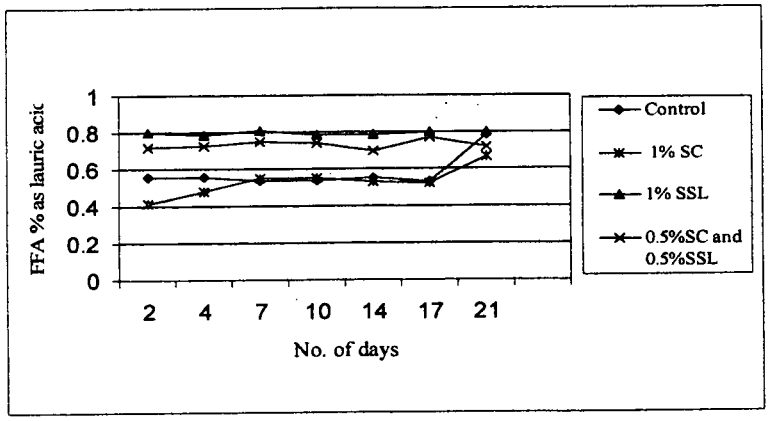

Fig.3.1 ***Variation of FFA of coconut milk processed with different type of stabilizers***

SC- sodium caseinate; SSL-sodium stearoyl lactate

The figure 3.1 shows the variation of free fatty acid contents during the storage of coconut milk processed with different stabilizers. All the treatments showed an acceptable free fatty acid contents, i.e less than 1%. The free fatty acid contents of stored samples were stable up to 17

days. The sample treated with 1% sodium caseinate and the control showed an increasing trend while the combination of 2 stabilizers and 1% sodium stearoyl lactate showed a stable FFA content. During the processing of milk the FFA levels increased slightly due to handling and it was stabilized due to the heat treatment and low temperature storage. Brix value of the control was 9 and it is 10 -11 in other treatments. This may be due to the addition of the stabilizer during processing. The addition of the stabilizer can cause an increase in the total soluble solid content in coconut milk.

Layer separation

The figure 3.2 shows the stability of emulsion with added stabilizers. Layer separation was not observed in treatment 3 where a combination of 2 stabilizers (0.5% sodium caseinate and 0.5% sodium stearoyl lactate) was used. Treatment 1 (1% sodium caseinate) and the control showed a clear separation whereas the sample treated with 1% sodium stearoyl lactate gave a comparatively low separation. The results indicated that combination of stabilizers is more suitable than a single stabilizer. However, all the samples remained with good organoleptic conditions at the end of 17 days.

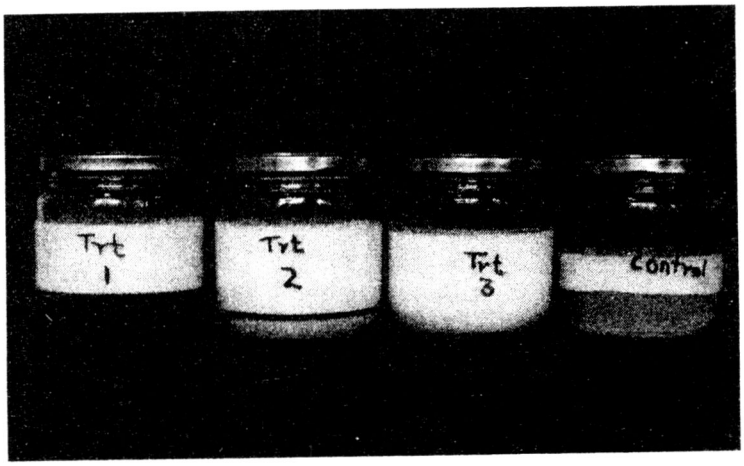

Fig. 3.2 ***Emulsion stability of processed coconut milk with stabilizers***
(Trt 1 – 1% sodium casinate; Trt 2 – 1% sodium stearoyl lactate ; Trt 3 – 0.5% sodium casinate + 0.5% sodium stearoyl lactate; control – no stabilizer)

Pasteurization temperature

Coconut milk was pasteurized at different time intervals at 72°C. This experiment was carried out in order to determine the best time and temperature combination for pasteurization. Based on the results of a previous experiment, a combination of stabilizers (0.5% sodium caseinate and 0.5% sodium stearoryl latate) was added to the coconut milk at 55°C while shaking. Then the milk was pasteurized at 72°C for 10, 20, and 30 minute intervals. No heat treatment was given to the control. The pasteurized coconut milk was filled into jam bottles and was stored at 4°C for 4 weeks.

Figure 3.3 shows the variation of FFA of pasteurized coconut milk stored for four weeks. After 19 days of storage, control samples were organoleptically unacceptable. The FFA value of control sample exceeded 1% as lauric acid indicating that it is chemically unacceptable after 19 days of storage. The organoleptic evaluation also showed that it was unacceptable. Sour taste and off odor were observed in the control sample which may be due to the low heat treatment given. All the other samples were within the acceptable level of FFA. Organoleptic evaluation showed that the heat treated samples remained in good condition during storage period.

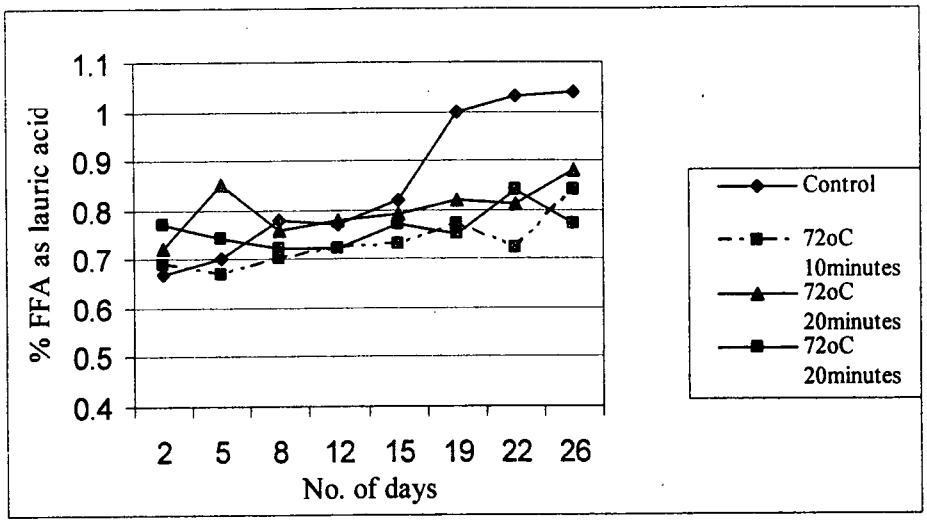

Fig. 3.3: ***Variation of FFA of coconut milk processed at different conditions***

Microbial analysis

Table 3.2 shows the variation of initial microbial plate count during storage. The initial microbial count of the control sample and the sample treated for 10 minutes showed higher values (2.03×10^5 and 2.23×10^5 Colonies/ml) than the other treatments. The initial value increased during storage. The results showed that the microbial count decreased with the time of heating. Therefore heat treatments are necessary for the storage of coconut milk packed in pouches.

Table 3.2 ***Total Plate Count (colonies/ml) of heat treated coconut milk stored for three weeks.***

Days	Colonies/ml			
	Control	72°C; 10 minutes	72°C; 20 minutes	72°C; 30 minutes
0	2.03×10^5	2.23×10^5	4.32×10^3	3.6×10^3
7	4.3×10^6	1.02×10^6	1.62×10^5	1.05×10^5
14	5.42×10^6	1.49×10^6	1.74×10^5	3.2×10^5
21	1.21×10^7	2.23×10^6	6.15×10^5	4.2×10^5

Suitable packaging materials

Coconut milk was processed with conditions selected from previous experiments and then packed in two types of packaging materials; nylon polyethylene and aluminum laminated polyethylene for storage. The pouches were stored at 4°C for 4 weeks. The fig.3.4 showed that the FFA values for both packaging materials are less than 1% and they are acceptable for consumption. The ANOVA showed that there is no significant difference ($p>0.05$) in FFA value between nylon and Aluminum pouches ($p = 0.107$). Therefore, the two types of packaging materials suitable for packaging of coconut milk.

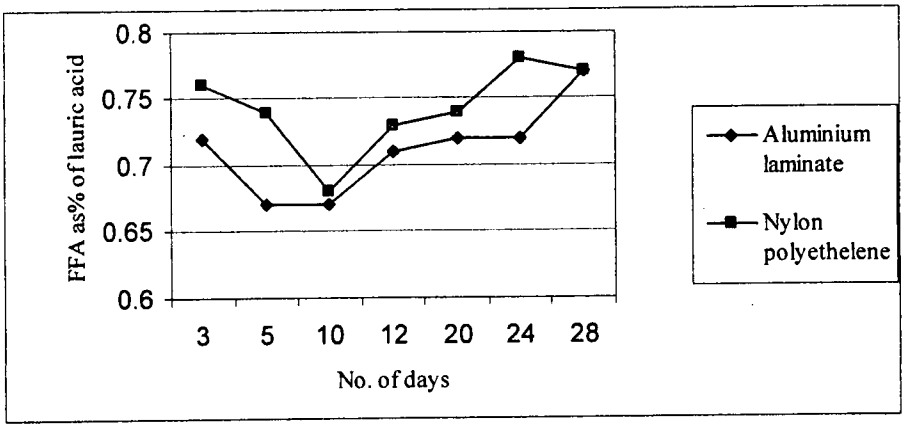

Fig.3.4: ***Variation of FFA of coconut milk packed in different packaging materials***

Sensory evaluation

Consumer preference test was performed for processed coconut milk pouch. Two sensory evaluations were carried out with different storage intervals. Sago was cooked using stored for 2 and 4 weeks coconut milk pouches and fresh coconut milk (control). They were served to panelists for evaluation of sensory attributes such as taste, texture, aroma and overall acceptability. According to table 3.3 there is no significant difference between fresh milk and samples stored for two weeks at 0.05 level of significance. The panelists scored more than 6 for all the attributes. They gave high marks for the fresh milk but they have put all the attributes in one group except the texture.

Table 3.3: ***Probability values and mean sensory scores for processed coconut milk stored for different time intervals.***

Attribute	Mean sensory scores					
	Two weeks			Four weeks		
	P value	Fresh milk	Stored milk	P value	Fresh milk	Stored milk
Taste	0.361	6.85	6.54	0.323	7.45	7.04
Aroma	0.495	6.42	6.15	0.633	6.54	6.27
Texture	0.100	6.61	5.91	0.006	7.50	6.14
Overall acceptability	0.855	6.82	6.39	0.219	7.45	6.91

Probability value ($P<0.05$) significant difference

The processed coconut milk contains a stabilizer which could make the texture of hard while sago cooked with fresh milk is soft. There was a significant difference between fresh milk and milk stored for four weeks. The texture of stored milk significantly differed from the fresh one. The other attributes did not change significantly. The reason may be due to the effect of stabilizer added to get uniform consistency. The results showed that processed coconut milk remained in good condition even after 4 weeks when stored at 4°C.

Coconut milk can be preserved using mild heat treatments. Layer separation can be overcome by using a combination of 2 stabilizers, 0.5% sodium caseinate and 0.5% sodium stearoyl lactate. The heat treatment of pasteurization is 72°C for 20 and 30 minutes. Suitable packaging materials for packaging of processed coconut milk are nylon polyethylene and aluminum laminated polyethylene. The processed coconut milk can be preserved for 4 weeks at 4°C. Further studies are needed for commercialization of the process.

L.L.W.C. Yalegama and P. Ambigaipalan (University of Peradeniya)

Experiment: 4 Quality and shelf life improvements of coconut paring oil

Coconut paring oil is produced in most of the DC mills in Sri Lanka and is used only for industrial purposes due to its poor quality. Normally it deteriorates very quickly. Therefore a study was conducted to improve the process/ quality of paring oil. Three treatments; Oil type-1- Parings oil extracted at CRI using wet paring obtained from Dunagaha mill, Oil type-2- Paring oil extracted at CRI using dry parings obtained from Dunagaha mill and Oil type-3- Paring oil extracted at Dunagaha mill included.
The moisture content of good quality paring/white oil should be less than 0.4-0.5% and free fatty acids content should be below 0.8% as given in the SLS 32:2002 (Specification of coconut oil).

Initial moisture content of oil type 1 was 0.15% and it was 0.3% and 0.68% for types 2 and 3 respectively. The results indicated that the moisture content of paring oil processed at Coconut Research Institute were within the limit of SLS specifications. The moisture content of paring oil processed at Dunagaha mill was high. The Free fatty acid contents (FFA) were 0.85%, 2.35% and 4.68% for the types 1,2,and 3 respectively. The FFA value of paring oil processed at Coconut Research Institute using wet paring was much lower than the other two samples. This could be due to the maintenance of proper hygienic condition of processing of oil. Thus by improving the method of processing of coconut parings, the quality of oil can be increased. The samples were treated with 0.1% citric acid, nitrogen purging, activated charcoal and a control.

The samples treated with 0.1% cirtic acid contained a higher moisture content in all three types of oil with respect to the control (untreated). Treatments with nitrogen purging and activated charcoal reduced the moisture content when compare to the control. The treatments could not reduce the FFA levels of all 3 types of oils.

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Experiment 5: Development of Heat Recovery Unit for Production of Good Quality Charcoal and Dried Pulverized Kernel

In Sri Lanka, the traditional charcoal production is done by pit firing. In this method, a considerable amount of heat is wasted and the smoke emitted causes environmental pollution. Hence, it is essential to develop alternative technology to address this issue. In this project, a prototype gasifier which has 15 Kw thermal capacity was developed using crushed coconut shells as a source of fuel. The particle size of the crushed coconut shell is 2"-2.5" and it contains 10% moisture. According to initial test trials, a combustible producer gas was generated. Due to the initial success of this, the proto type gasifier was scaled upto 60 Kw thermal rating gasifier having a feeding capacity of 16- 20 Kg /hr crushed coconut shell. It was possible to achieve a 20 % (wt/wt) charcoal out put.

Controlling of the tar liquor and removal of ash particles were two issues that needed to be addressed. The presence of volatile matter including tar liquor would be effectively avoided by proper insulation and full burning. Similarly, ash particles in the producer gas are needed to be removed by a cyclone separator. The fabrication of a cyclone separator using locally available material was completed. This will help to overcome disturbances inside the burner and heat exchanger.
The producer gas coming out of the cyclone separator is intended to pass into the gas burner. A burner was also fabricated using locally available material. When the gas was passed into the burner, it gave a yellowish red colored flame with a temperature reaching 850°C. Most importantly, the flue gas coming out of the burner is colorless satisfying the requirement for

environmental pollution control. However, further fine tuning of the burner is required to go for full combustion of the gas so that a blue colored flame with a high temperature could be expected.

The heat generated by the flame can be transferred to a dehydration chamber via a heat exchanger to produce dried pulverized kernel. The moisture content of input fresh coconut kernel is 47%. It is expected to reduce the moisture content up to 2-3 % .The optimum temperature for drying is 70°C.
For this purpose, an efficient four pass shell and tube heat exchanging system has been fabricated. All the components are assembled together to build the heat recovery unit. The test trials were conducted for trouble-shooting. Some problems such as gas leakages, break down of burning front and fluctuation of producer gas quality could be solved successfully. The performance of the unit is at an acceptable level. With the available raw material, an efficient tray - type drying chamber which has capacity of 160 Kg of pulverized kernel was fabricated. The completed heat recovery unit has been installed at Bandirippuwa Estate.

J.R.K Asanka, J.M.N.Marrikkar

Experiment 6: Identification of microbes enhancing the retting process

Retting is the preliminary step of extracting brown and white fibre for the coir industry. Since conventional retting process takes more than six months, a study was undertaken to develop an appropriate technology to reduce the retting period and to improve the productivity of coir fibre industry.

From previous experiments, a consortium of microorganisms consisting of *Bacillus firmus, Bacillus macerans and Bacillus badius* was selected as highly effective microbes in retting process.

The pilot scale experiments are being conducted at Dunkannawa Research Centre using the selected consortium of microbial strains (consortium of microorganisms consisting of *Bacillus firmus, Bacillus macerans and Bacillus badius*). Experiments are being conducted in 7000ft^3 capacity tanks. Two tanks were filled with 2000 ft^3 water. Culture samples (450 liters of culture sample) were added to each tank and stirred well. Then 5000 husks were soaked in each tank. The husk samples were subjected to the retting process up to 21 days. To test the quality of fiber, 100 retted husks from each tank were defibered using the Ceylon drum. To compare the effectiveness of retting, physico-chemical parameters such as pH, EC, Plate Count of the ret liquor samples were also determined in each tank. The results indicated that the pH and temperature was similar in the ret liquor of treated and the control samples while electrical conductivity and the total plate count of the ret liquor from treated samples were higher than that of the control. However, the plate count was not sufficient for efficient retting process (~ 10^3-10^4 microbes /ml). Physical parameters of fibre extracted from treated and control samples showed that treated samples were higher in breaking strength (5.4 N) and tensile strength (116.6N/ mm^2) when compared to the fiber extracted from the control sample. The experiments are in progress to improve the process further and to obtain better quality bristle fibre. Finding a low cost storage growth media is also in progress.

J.A.K.M Fernando and T.M.S.G Weerasinghe

Experiment 7: Development and Improvement of coconut fibre based products

Coconut fibre 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 uses. Development and improvement of coconut coir products are essential in gaining a premium price for such products.

Basically coir pots, turfs, weed mats and bags (for domestic use) were produced using mixed coir fiber and compounded rubber latex. Experiments are underway to confirm the effectiveness of the turfs and weed mats.

Experiments were also carried out for the manufacture of coir composites like fiber boards and ceiling sheets. Ceiling sheets were manufactured by changing the composition of fiber and cement to achieve the recommended quality parameters. Further it is intended to evaluate the physico-mechanical properties of the sheets by manufacturing them utilizing different types of coir fiber such as bristle, mixed and fibers of different sizes available in coir fiber mills in Sri Lanka.

J.A.K.M Fernando and N.S. Witharana

TECHNOLOGY TRANSFER ACTIVITIES

The staff conducted 22 demonstrations to promote coconut products in Vidatha centers.

ACKNOWLEDGEMENT

The co-operation and assistance extended by staff of the Coconut processing Research Division in conducting experiments is greatly acknowledged. The cooperation extended by staff of Soils and Plant Nutrition Division and Plant Physiology Division is also greatly acknowledged.

REPORT OF THE PLANT PHYSIOLOGY DIVISION

Head – C S Ranasinghe, Ph D

SUMMARY

Research programme of the division was conducted under two main thrusts, crop improvement and crop production. Evaluation of vigour of dwarf hybrids under moisture limited conditions was disturbed due to the absence of substantial dry spells with well spread rainfall in all three experimental sites during the year. Recording of flowering and yield data was started in the experiment conducted to determine the effect of irrigation on the vegetative growth, flowering time and yield characters of tall and hybrids in different land suitability classes at Wanathavilluwa (DL_3). The collection of yield data on individual palms at different distances from the rain water harvesting tank along the upper and lower elevations was started to identify the effective area and to quantify the impact of the rain water harvesting on the yield. Flowering was already started in the experiment conducted to evaluate a model drought management system for mini coconut triangle at Middeniya Research Centre. The hybrid Kapruwana showed early flowering followed by the hybrid Dwarf x Tall (DT, CRIC 65) just within two and half years after planting. Heat based sap flow techniques appeared promising to evaluate the water status of coconut palm under field conditions and indicated the possibility of using this method for screening coconut varieties for drought tolerance. The mean daily total sap flow (F_d) of DT palms in S_2 soil in the Wet Zone was 76% greater than that of Intermediate Zone whilst the F_d of DT palms in S_4 in the Wet Zone was 40% greater than that of Intermediate Zone. The results revealed that F_d is affected by both soil type as well as the climatic condition of the different agro-ecological regions.

New experiment started in June 2008 explores the possible reasons for yield fluctuation in coconut in wet, intermediate and dry zones under S_2 and S_4 land suitability classes. This study determines the dynamics of dry matter production and partitioning, nut set and yield of coconut with respect to solar radiation intensity, air temperature and duration of dry spells during the development of coconut inflorescence, total set nuts (nut load) of the palm and pollen quality. A model was developed for Tall x Tall (TT) variety in order to estimate the dry matter partitioning to developing nuts using an easily measurable non-destructive parameter.

The project on the impact of climate change on coconut plantations, started in April 2008, focuses on different aspects such as effects of high temperature and water stress during pre- and post-anthesis stages of inflorescence development on pollen quality and fruit set, screening coconut varieties for high temperature tolerance by *in vitro* pollen germination and pollen tube length and identifying sensitive stages of coconut inflorescence development cycle to climate change.

The protocol for quality preservation of tender king coconuts for a period of one month was obtained by 8 exporters/growers and permits were issued for exporting 21 consignments of preserved king coconuts during the year. Research programme of the division was conducted using the consolidated funds.

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)

Evaluation of hybrid vigour of different dwarf brown crosses using physiological characteristics was conducted during previous years under moisture non-limiting conditions. The scheduled evaluation of varietal differences under moisture limited conditions was disturbed due to the well spread rainfall without prolonged dry spells in all three experimental sites i.e. Raddegoda (IL3), Rathmalagara (IL_1) and Wanathavilluwa (DL_3) during the year. Data collection is scheduled to be conducted in subsequent dry spells in all three experimental sites.

A Nainanayake, H C Mendis, R D N Premasiri & L R S Silva

THRUST AREA: CROP PRODUCTION

PROJECT: STUDIES ON WATER, LIGHT, HEAT STRESS AND ELEVATED CO_2 EFFECTS ON PRODUCTIVITY

Experiment: Effect of irrigation on physiological, vegetative and yield characters of Tall x Tall and Dwarf Green X Tall crosses

This experiment was started with the objective 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. The preliminary experiment was started at one site in Thapal watta, Wanathawilluwa in DL_3 AEZ (Latasol & regosol region of the dry low country region) with two land suitability classes i.e. S_2 (suitable to highly suitable) and S_3 (suitable) with two commercially available improved coconut cultivars (CRIC 60 and CRIC 65). Details of the experiment were reported in previous year.

A few seedlings mainly the hybrids (DT) have just come into flowering and data recording was started on flowering time and yield parameters. New irrigation system is yet to be installed to replace the manual irrigation conducted using water bowsers. Experiment is in progress.

A Nainanayake, H C Mendis, R D N Premasiri & L R S Silva

Experiment: Yield improvement in coconut lands by Rain water harvesting techniques

Coconut is highly concentrated in the intermediate zone of Sri Lanka which receives substantial rainfall but with high-intensity within short-durations. Therefore, more than 70% of rain water is lost as surface runoff causing soil erosion and nutrient losses. Harvesting such runoff water in small rain water harvesting tanks (pathaha) would help to maintain the water table during subsequent dry spells and replenish deeper soil layers while reducing the soil erosion and nutrient losses during rainy period. The objective of this experiment is to construct rain water harvesting tanks with suitable catchment areas in CRI estates and to improve soil water availability during subsequent dry spells. This practice will help to reduce crop losses during dry spells and thus reduce yield drops in effective area of the surrounding coconut plantation.

Although it was scheduled to construct a number of such rain water harvesting tanks in CRI estates, only one main tank was constructed due to the financial constraints for preliminary evaluations at Bandirippuwa estate with the capacity of 4600 m^3 (3.72 acre feet) in field no 7. Some positive impacts observed on the annual yield of the entire field were reported in the previous year. The collection of yield data on individual palms at different distances from the tank along the upper and lower elevations was started to identify the effective area and to quantify the impact of collected water on the yield in the particular soil type where the tank existed. Experiment is in progress.

A Nainanayake, L R S Silva

Experiment: Evaluation of a model drought management system in Middeniya research station

Middeniya area in the Hambantota district receives an average rainfall of about 1300 mm with two peak periods in October- December and March-May, even with a substantial dry spell from June to September each year. These dry spells result in a marked reduction in yield in the area. However, the average annual rainfall and its monthly distribution for last two decades revealed a possibility to reduce the effects of dry spells substantially, if proper soil moisture management practices are adopted. Therefore, the objective of this experiment was to develop a new coconut plantation with an overall drought management practices (mulching, husk burial, incorporation of organic material, introduction of cover crops (*Peuraria*) and some nitrogen fixing trees (*Gliricidia*)). All improved cultivars released by CRISL so far [Tall x Tall (CRIC 60), Dwarf x Tall (CRIC 65), Tall x San Ramon (CRISL 98), Dwarf Green x San Ramon (Kapruwana) are evaluated with a local accession collected from Rumassala in Southern Province. Five coconut cultivars in three blocks under three treatments were planted with 9 seedlings per plot in Randomized Complete Block Design. There are three treatments i.e. the control with only fertilizing but without any soil moisture conservation practices, application of overall soil moisture conservation practices and irrigation @ 40 litres per palm per day during droughts in adult stage. Irrigation is started after a continuous rain-free period of 15 days. Details of the experiment were given in the report of the previous year.

Flowering is already started in experimental plots just within two and half years after planting where the hybrid Kapruwana showed the early flowering followed by the hybrid DT (CRIC 65) while all Tall forms are yet to flower. These early flowering was mostly observed in the T_2 treatment which contains the all soil moisture management practices together. No significant difference was observed between the control (T_1) and irrigated plots (T_3) because the irrigation with the scheduled quantity and the frequency was started only recently due to the delays in the construction and installation works of the irrigation system. However, it is too early for any detailed analysis. Data recording on flowering and yield is in progress.

A Nainanayake, H C Mendis, L R S Silva & R D N Premasiri

Experiment: Yield fluctuation in coconut in relation to solar radiation intensity, air temperature, dry spells, total set nuts (nut load) and pollen quality

Yield fluctuation in coconut is well evident and it is clear that this fluctuation is not governed by a single factor such as rainfall pattern of the preceding year. Coconuts grown in different Agro-ecological zones of Sri Lanka are exposed to different intensities and durations of solar radiation, temperature, vapour pressure deficit and dry spells. Therefore, environment stresses such as low light intensity, heat and long duration of dry spells can be considered as important factors determining nut set and yield in coconut. Nut set, an important yield determining factor, mainly depends on the source to sink ratio of the plant in addition to pollen quality. Source strength varies with the light interception by the canopy in addition to water and nutrient supply whilst and sink strength varies with the total number of nuts in developing bunches. A large portion of the produced assimilate is lost by respiration, thereby decreasing assimilate available for growth and development of the plant. The dynamics of dry matter production, dry matter partitioning and changes in nut set in relation to climatic conditions during sensitive periods of inflorescence development have not been studied in detail in coconut. Therefore, the objectives of this experiment are to determine the seasonal variation in dry matter production, dry matter partitioning to reproductive and vegetative organs, nut load of the palm, viability and germination of pollen and their impact on nut set and yield of coconut in different ACZ under S_2 and S_4 land suitability classes.

Three sites were selected in wet (WZ), Intermediate (IZ) and dry zones (DZ) for the study. Ten palms each from S_2 and S_4 land suitability classes were randomly selected from each site. The plantations were of uniform age (25-26 years) and density, and receiving uniform agronomic and cultural practices.

Locations and agro-climatic conditions of the sites:

Location	*Soil type*	*Agro-Climatic Zone*
Urapola (Gampaha District)	Pallama series – S_2 Boralu series – S_4	Wet
Wellawa (Kurunegala District)	Kurunegala series – S_2 Kuliyapitiya series – S_4	Intermediate
Mangala Eliya Madurankuliya (Puttlam District)	Mavillu series – S_2 Mampuri series – S_4	Dry

Data collection on number of set nuts per bunch (monthly), number of retained nuts in each bunch (monthly) growth rate of nuts in each bunch (monthly), growth rate of trunk (six monthly), leaf area Index (six monthly), leaf production rate (monthly), rate of photosynthesis (monthly) and percentage viability and germination of pollen (monthly) was started in June (WZ and IZ) and July (DZ) 2008. Daily climate data are obtained from the Biometry Division to determine the sensitivity of growth and yield parameters to climate.

C S Ranasinghe, H C Mendis, L R S Silva & W P K K Fernando

Experiment: A non-destructive method for estimating the dry matter accumulation in developing coconuts

The development process of a coconut takes about 11-12 months. The rapid increase in nut size takes place from second to sixth month, nut water accumulates from third to fourth month onwards, kernel formation starts from fifth to sixth month and shell formation / hardening starts from sixth to seven months after fertilization. The crown of a healthy palm generally consists of 14-16 coconut bunches of different developing stages. When the monthly variations in dry matter

partitioning to developing nuts are studied (as in the previous experiment), there should be a non-destructive method or model to estimate dry matter content of nuts at each developing stage using easily measurable parameters. The effort of this study is to explore the possibilities of such models. Therefore, the objective of this study was to develop a model to estimate dry matter content of developing nuts in TT and DT varieties using nut length parameters.

Thirty healthy coconut palms (TT) were randomly selected from Makandura Genetic Research Centre (Wet Intermediate zone), Ratmalagara Research Centre (Intermediate Dry zone) and Pallama Genetic Research Centre (Dry zone) to cover different environmental conditions that would affect the growth of nuts and fruit components. Ten palms from each station were selected. All the palms are of uniform age (25–28 years) and nut load (visual observations).

One nut from each developing bunch, from 1-month old button nuts to harvest-ripe nuts, were harvested (12 to 16 bunches per palm). Data on nut length (along vertical and horizontal axes), dry weights of husk, shell, kernel and nut water (when present) of each nut were collected and total dry matter content of the nut was determined. The relationship between nut dry matter content and length of developing nuts was estimated using regression analysis (SPSS v13). The values of total dry matter content of the nut (DM) were natural log transformed to achieve the linearity of the model. As nut lengths of two directions (vertical and horizontal) are strongly related, the length along vertical axis (L-vertical) was selected for the model as the best predictor to avoid multi-co-linearity in the model.

$$DM\ log = 0.1486 + (0.1472\ (L\text{-}vertical)) - (0.000741(L\text{-}vertical)^2)$$

DM; Total dry matter content of the nut (g), L-vertical; length of the nut along the vertical axis (cm)

The model was validated using nuts collected from Bandirippuwa Estate (wet intermediate zone). The estimated dry matter content of nuts agreed well with the measured values ($r^2 = 0.94$). Further improvement of the model developed for TT variety and the model development for DT variety are in progress.

C S Ranasinghe, P Widyaratne (Biometry Division) & R D N Premasiri

PROJECT: IMPACT OF CLIMATE CHANGE ON PRODUCTIVITY OF COCONUT PLANTATIONS

Experiment: Identification of sensitive stages of development cycle of coconut inflorescence to climate change

The stages of coconut inflorescence development from primordial initiation to the inflorescence opening takes about 26 months and from female flower fertilization to nut maturity it takes about 12 months. Therefore, it is very important to determine which of the stages in the ontogeny of coconut are more critical in determining the final nut yield and what are the most significant climatic factors affecting those stages. The 'sensitive stages' of inflorescence development such as primordial initiation (-26 stage; 26 months before opening), formation of floral organs (-8 stage), differentiation of reproductive organ primordial (-6 stage), sex determination (-4 stage), ovule and pollen formation (-3 to -1 stage) and button nut formation (1-2 months after

fertilization) (Perera, 2008) can be adversely affected by prevailing climatic conditions. Therefore, the objective of this study is to determine the relationship between monthly coconut yield and climate factors during critical stages of inflorescence development, using secondary data collected over past five consecutive years in different AER.

The relationships between duration of exposure to low light intensity, rain free days and high temperature at critical stages of each inflorescence development and yield of coconut will be determined. Finally, the possibility of using these relationships to predict coconut yield will be explored.

C S Ranasinghe, P Widyaratne (Biometry Division)

Experiment: Effect of environmental stress conditions during pre- and post-anthesis stages of inflorescence development on pollen quality and fruit set in coconut

Sexual reproduction in plants is more sensitive to high temperatures and water stress than vegetative processes, and therefore, plant reproductive organs will be more vulnerable to changes in short episodes of stress prior to and during early flower stage. The impacts of stress are mainly determined by the intensity, timing of exposure (sensitive period), and the duration of exposure to these stress conditions. It has been reported that the principal deleterious effect of high temperature and water stress is on fruit set and the reduced fruit set is mainly due to a reduction in pollen viability and release (megasporogenesis is less affected), and this was mainly attributed to the disruption of sugar metabolism during male reproductive development.

The most sensitive stages of coconut reproductive phase to these stress conditions are not clearly understood and the degree of sensitivity and the pattern of reaction to environment stress may differ among varieties. Therefore, the objectives of this study were to determine the monthly variation in pollen quality and its impact on fruit set in different varieties of coconut and to identify sensitive stages of inflorescence development to high temperature and water stress.

Experiment was started at the Bandirippuwa Estate, CRI in April 2008 using three selected varieties, Tall, San Ramon and King Coconut. Eight palms from each variety were selected randomly and data on inflorescence opening date, percentage pollen viability and germination, starch and soluble sugars of mature pollen, number of female flowers, set fruits (after 2 months) and final yield are being recorded for each and every inflorescence. Daily climate data are obtained from the Biometry Division to determine the response of the growth and yield parameters to climate. The pattern of carbohydrate metabolism in the final stages of developing anthers is determined by analysing the starch and total soluble sugar content of developing anthers at -4, -3, -2 -1 and 0 (mature pollen) stages.

C S Ranasinghe, W P K K Fernando, S Thimothias (Sabaragamuwa University) & T Rasnayake (Wayamba Universiy)

Experiment: Screening coconut germplasm for high temperature tolerance by *in vitro* pollen germination and pollen tube length

Fruit set in many crops is sensitive to high temperature. The optimum mean air temperature range for coconut is reported as 27°- 29°C. Coconuts grown in intermediate and dry zones are often exposed to brief, or sometimes prolonged period of heat stress, i.e. day time temperature warmer than 30-32°C (T_{max}). In addition, short episodes of extreme events including high temperature projected to occur more frequently in the future climate will impact fruit set and yield. Therefore, it would be advantageous for plants to exhibit greater reproductive

survivability at extreme temperatures normally encountered during plant reproduction and for processes leading to fruit set such as pollen germination and pollen tube growth.

Pollen, once released from the anthers, acts as an independent functional unit and is exposed to ambient environment. In coconut, anther dehiscence occurs during the morning hours and pollen germination will start upon contact of a receptive stigma. Consequently, high temperatures during pollen germination (from morning till afternoon) can severely affect fruit set and yield. The cardinal temperatures (T_{max}, T_{opt} and T_{min}) for percentage pollen germination and pollen tube length identified using *in vitro* pollen germination studies can be used to screen the varieties for high temperature tolerance. However, to date, there have been no studies conducted to identify this variability in coconut. The objectives of this research were to (1) quantify the responses of *in vitro* pollen germination and pollen tube growth of different varieties of coconut, (2) determine the cardinal temperatures of different varieties and (3) develop a screening technique to identify varieties tolerant to high temperature.

Experiment was conducted with 11 temperature regimes and seven varieties. The varieties under evaluation are Tall (TT), San Ramon (SR), Dwarf Brown (DB) Dwarf Green (DG) Dwarf Red (DR) Dwarf Yellow (DY) and King Coconut (KC). Pollen is germinated in a modified germination medium at different temperature regimes; 20°, 22°, 24°, 26°, 28°, 30°, 32°, 34°, 36°, 38°, and 40°C. After 24 hrs of incubation, percentage pollen germination is determined and pollen tube is measured. A preliminary experiment showed that percentage pollen germination (% PG) was optimum at 28 °C and it reduced to 50% and 25% of the optimum value at 33 °C and 36 °C, respectively.

C S Ranasinghe, S Thimothias

PROJECT: STUDIES ON ROOT GROWTH, ROOT ACTIVITY AND ROOT FUNCTIONS IN RELATION TO WATER AND NUTRIENT UPTAKE

Experiment: An Investigation of drought tolerance mechanism in coconut (*Cocos nucifera* L); with particular reference to roots

Heat based sap flow techniques have so far not been used for coconut to estimate plant water status or to evaluate drought tolerance mechanisms. Therefore, particular attention was paid to investigate the possibility of using the heat based sap flow techniques to evaluate the plant water status of TT and DT palms under field conditions to explore the possibility of using this method for screening purposes. Compensation Heat Pulse Method (CHPM) was used to measure the sap flow in palms. Heat pulse velocity was determined by this method in DT and TT coconut palms grown under two different land suitability classes (S_2 and S_4) in two Agro-Climatic Zones (WL_2 and IL_1). The details of the results on TT palms were reported in the Annual Report of 2007.

Sap flow of DT palms grown in S_2 and S_4 soils in Intermediate Zone (IZ)

Sap flow of DT palms grown in S_2 soils in the IZ was determined during the period of 14th February to 21st February 2008 (palm 1) and from 13th March to 19th March 2008 (palm 2). The maximum hourly sap flow (F_h) varied between 9 and 11 L hr^{-1}. The mean daily total sap flow (F_d) of P_1 was 91.14 L day^{-1} where as it was 85.94 L day^{-1} in P_2 (LSD = 27.45). There was a close relationship between F_h and hourly climate data (Table 1).

Table 1: ***Relationship between hourly sap flow and hourly temperature, solar radiation, vapour pressure deficit and relative humidity for the DT palm grown in S_2 soil suitability class in IZ***

Climatic factors	R^2
Temperature (T) (oC)	$R^2 = 0.76$, $Y = 0.65x - 10.6$
Solar radiation (SR) (W m^{-2})	$R^2 = 0.60$, $Y = 0.001x + 4.53$
Vapour Pressure deficit (VPD) (kPa)	$R^2 = 0.74$, $Y = 2.94x + 4.36$
Relative Humidity (RH) (%)	$R^2 = 0.78$, $Y = 0.14x + 17.76$

Sap flow determination of the DT palms in S_4 soils was done during the period from 21st to 29th February (Palm 1) and 7th to 13th March 2008 (Palm 2) and the daily total sap flux of these palms ranged from 67 to 87 L d^{-1} with an average of 79 L d^{-1}. Hourly sap flux (F_h) of both palms showed a close relationship with hourly climatic data (T, SR, RH and VPD) as for the DT palms on S_2 soils.

The average daily total sap flux of DT palms grown on S_2 and S_4 soils in IZ showed significant variation ($p<0.05$) between two soil types. The average sap flow of DT palms grown on S_2 soils were at least 15% higher than on S_4 soils indicating the effect of soil suitability class on the amount of water movement of palms.

Sap flow of DT palms grown in S2 and S4 soils in WZ

This experiment was conducted in DT palms in S_2 (Palm 1 during 27th March – 4th April 2008 and Palm 2 during 30th April- 06th May 2008) and S_4 soils (Palm 1 during 4th April – 12th April 2008 and Palm 2 during 17th April- 24th April 2008) in wet zone using two palms under each category. Significant palm to palm variation in the maximum hourly sap flow or daily total sap flow (F_d) was not observed within the soil type, but between soil types, there was a significant difference. The average F_d of DT palms grown in S_2 was 162 L Day^{-1} while it was 112 L Day^{-1} on S_4 soil. This indicates that the average daily total sap flow of DT palms grown in S_2 soil has 44% greater sap flow than DT palms grown in S_4.

In conclusion, DT palms in S_2 soil in the WZ had 76% greater F_d than DT palms grown in S_2 in the IZ while DT palms in S_4 in the WZ showed 40% greater F_d than that of IZ. The results indicate that F_d is affected by both soil type as well as the climatic condition of the different agro-ecological region.

W S Madurapperuma, L R S Silva

MULTI DISCIPLINARY PROJECTS
Project Coordinator – C S Ranasinghe, Ph D

THRUST AREA: CROP PRODUCTION

Participating Divisions: Plant Physiology Division
Soils and Plant Nutrition Division
Crop Protection Division

Summary

Five different treatments were imposed to investigate the improvement / recovery of LSD, TD and CRD-affected palms in Makadura Research Station. Although no significant improvements were observed within the second year after treatment application with respect to most of the canopy and yield characteristics, some positive trends were observed in parameters related to root growth. When the effect of Poultry manure + Coconut Shell Charcoal (T_2), Vermicompost (T_3) and Commercial Compost (T_4) on root growth, development and root distribution pattern of LSD affected coconut palms was investigated, the total number, length, density and dry weight of live roots and root distribution in the soil profile were highest in palms treated with Poultry manure + Charcoal (T_2). All the palms treated with soil conditioners (T_2, T_3 and T_4) showed an improved root growth compared to untreated palms (T_1).

PROJECT: STUDIES ON PLANT DISORDERS, LEAF SCORCH DECLINE (LSD), TAPERING DISORDER (TD) AND COCONUT RAPID DECLINE (CRD) OF COCONUT

Experiment: Assessment of the efficacy of various treatments on improvement/recovery of LSD, TD and CRD-affected palms

The main objective of this experiment was to evaluate the effect of different treatments on the recovery of decline symptoms of palms of three types of disorders i.e. Leaf Scorch Decline (LSD), Tapering Disorder (TD) and Coconut Rapid Decline (CRD) in Makandura Research Station (MRS). Coconut palms showing above three disorders (LSD. TD and CRD) were selected into an experiment with Randomized Complete Block design with five treatments (T_1, T_2, T_3, T_4, and T_5; details are given below), two blocks (B_1 covering S_2 Land Suitability Class (LSC) [*Halpe* series] and B_2 covering S_3 and S_4 LSC [*Kandetiya* and *Makandura* series]) with three palms per plot thus including 90 palms altogether for evaluation.

Treatments:

- T_1- Control (no specific treatment but with the basal application of 3 kg of APM and 1 kg of Dolomite per palm year)
- T_2 - Charcoal and poultry manure (90 kg of Charcoal and 60 kg of Poultry manure per palm per year; 3:2 ratio)
- T_3 - Vermicompost (60 kg per palm per year)
- T_4 – Oxytetracycline (5g of OTC / 5 ml of water per palm with two treatment applications a year)
- T_5 – Commercial compost (60 kg per palm per year)
- T_6- Irrigation (Application rate)

Canopy observations (Total number of fronds, number of affected fronds, length of the newly opened frond, length and the circumference at the broadest position of the inflorescence prior to opening, girth of the trunk just below the last leaf base and one foot below and canopy photographs to monitor the visual changes at the canopy) and yield parameters (total number of female flowers, number of set nuts, final yield and fruit components) were recorded in three-month intervals. No significant improvements were observed within the second year after treatment application with respect to canopy and yield characteristics.

The effect of three treatments (soil conditioners); T_2, T_3 and T_4 on root growth, development and root distribution pattern of LSD affected coconut palms grown under two different soil types was evaluated. Root samples were taken from two locations and four depths of the manure circle of each palm. The total number, length, density and dry weight of live roots and root distribution in the soil profile was higher in palms treated with soil conditioners (T_2, T_3 and T_4) than untreated palms (T_1). Total number of live roots, number of tertiary live roots ($P < 0.01$) and dry weight of tertiary live roots ($P < 0.001$) were significantly higher in palms treated with Poultry manure + Charcoal (T_2) than Control and other treated palms. These results suggest that application of Poultry manure and coconut shell charcoal may be a possible remedial measure on recovery of LSD- affected coconut palms. The same root study has to be done on the CRD and TD-affected palms and Furthermore, it is necessary to determine whether the improved root growth has a positive impact on the physiological, growth and yield parameters of the LSD, CRD and TD palms.

C S Ranasinghe, A Nainanayake, A Tennakoon, R Wijesekara, H C Mendis, R D N Premasiri, L R S Silva, M K F Nadheesha, U S S Perera, H.P.T.P Hewapathirana

Training and Extension Activities

Ms K S H Thimothias of Sabaragamuwa University of Sri Lanka completed her B Sc final year research project on 'Pollen quality, carbohydrate metabolism and fruit set in coconut: changes with variety, atmospheric temperature, agro-ecological region and soil type' from April to August, 2008 under the supervision of Dr. C S Ranasinghe.

Ms R M T K Rasnayake of Wayamba University of Sri Lanka completed her B Sc final year research project on 'Effect of temperature on viability, germination and carbohydrate content of pollen and fruit set in three different coconut (*Cocos nucifera* L.) cultivars' from March to July, 2008 under the supervision of Dr. C S Ranasinghe.

Acknowledgement

The co-operation and assistance extended by staff of the Plant Physiology Division in conducting experiments, data collection and in compiling this report is gratefully acknowledged.

REPORT OF THE AGRICULTURAL ECONOMICS AND AGRIBUSINESS MANAGEMENT DIVISION

Acting head - Dr. (Mrs) C.Jayasekera, PhD

1. SUMMARY

The research programme of the Division was aimed at five major studies namely a) exploring the hidden behavior of coconut land owners in land fragmentation b) To explore the relationship between land size and productivity of coconut lands c) To assess the attributes influencing the selection of brown coir fibre extraction technology d) To evaluate the factory level performance of virgin coconut oil expeller introduced by CRI and e) To collect and calculate the data on cost of production.

The Tea Rubber and Coconut Estate Board (Control of Fragmentation) is responsible for granting permission for fragmentation of coconut lands based on the information provided by the land owner. A study was conducted to examine whether there are any adverse selection procedures (i.e. hidden information) and/or moral hazard (i.e. hidden action) leading to ineffective control of coconut land fragmentation. The study revealed that there is a chance of misleading this Board since the Board depends on the subjective factors for the decision making. It is suggested to include objective factor, land suitability class and case by case monitoring by officials in granting permission for coconut land fragmentation.

Raising productivity of existing coconut lands is of paramount importance since the scope for increasing land extent under coconuts is very limited. A study was conducted to explore the relationship between land size and productivity. The study showed that there exists a significant negative relationship between land size and productivity of coconut lands in home garden and smallholdings sector. On the other hand productivity of estates increases as land size increase. Policy makers and regulatory agencies must take efforts to secure large estate from unnecessary fragmentation and fragmentation of smallholdings may be allowed if the separated lands are remained primarily with coconuts.

The study was carried out to explore issues regarding machineries used in brown coir fibre extraction (i.e. Sri Lankan Drum Pairs, Defibering Machine, D1 Machine). The findings imply that the issues related to capital, machine and labor are the critical in selecting a technology. Even though the Sri Lankan Drum Pair Machine is negatively preserved by the millers for its several characteristics, they believe it is the best method for extraction of high quality bristle fiber. Therefore, this machine should be improved to minimize skill labor requirement and productivity.

CRI has disseminated the technology of virgin coconut oil extraction for 12 entrepreneurs and eight firms were operating during last year. This study was conducted to find out the level of realization of the customer on the recommended virgin oil extraction technology for further improvements. Among several attributes five were below the mean i.e. a) re-salability of the residue, b) availability of spare parts, c) Price of the machine, d) Automated safeguard and e) power consumption of the machine. These attributes should be considered for further improvement of this technology.

A survey was implemented to find out the actual cost of production of coconuts and Farm Record Books were distributed among the selected coconut growers.

2: RESEARCH PROJECTS

Area of Research 1: POLICY ISSUES RELATED TO COCONUT INDUSTRY

Research Project 1: Fragmenting Coconut Lands in Sri Lanka: Do Owners Show "Adverse Selection" and "Moral Hazard" Behavior?

Fragmentation of coconut lands has become a serious issue in Sri Lanka as there is evidence that around 250 coconut palms are lost per day due to unplanned land fragmentation. To minimize this, the Tea, Rubber and Coconut Estates (Control of Fragmentation) Board was appointed under the Act No: 20 of 2005, which specified certain criteria for transferring coconut lands, especially those with the ownership of more than four hectares. The permission to fragment a land is given by the Tea, Rubber and Coconut Estates (Control of Fragmentation) Board and the prospective applicant should forward an application. Since the selection of land for fragmentation is judged on the merits of information provided, many suggest that there exists the problems of "adverse selection" (i.e. hidden information) and/or "moral hazard" (i.e. hidden action) making the whole mechanism ineffective.

This study analyses the primary data from 50 applicants with the objective of examining the extent to which the yields specified in their applications deviated from the potential yield if the proper management practices were adopted. The results show that except in a single case, productivity of none of the lands was increased above the "potential level". Further, it shows that observed productivity of majority of the lands belongs to the Soil Suitability Class (SSC) S_1, S_2 and S_3 were even below the "potential" productivity of SSC S_4 and S_5 (Figure 1).

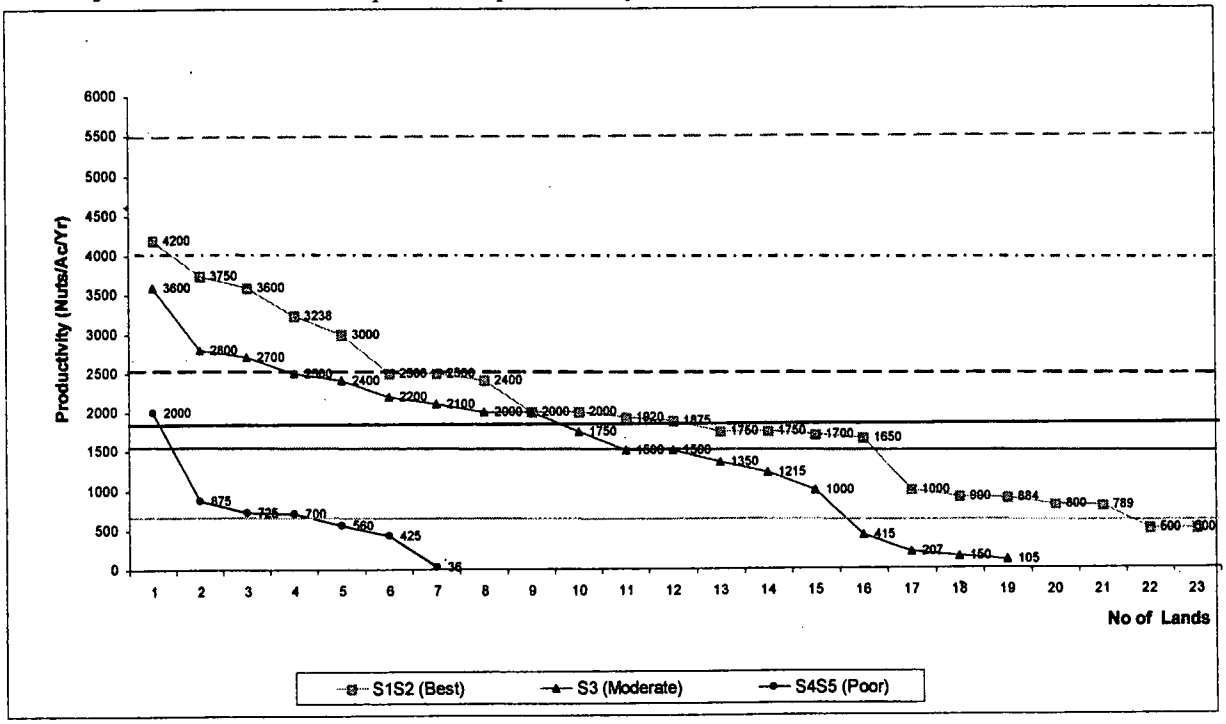

Figure 1: Relationship between productivity and Soil Suitability Classes

The suspected group represents nearly 22% of the sample (10% of "Poor", 8% of "Moderate", 4% of "Best"). Therefore, there is a chance to mislead the Fragmentation Board due to the dependency on subjective information which can be changed. The dependency on an objective factor like Soil Suitability Class and case-by-case monitoring by officials may help to minimize this behavior.

Another way of elaborating this problem is "Principal-Agent" problem where the officers may act as the agent and the land owner as the principal in information provision. This is another way of occurring moral hazard behavior in this process which we did not address.

Table 1: Distribution of land owners according to nut yield

Soil Category	Best (Observed Mean Nut yield = 1965)		Moderate (Observed Mean Nut yield = 1657)		Poor (Observed Mean Nut yield = 760)	
	Above Mean	Below Mean	Above Mean	Below Mean	Above Mean	Below Mean
Best (S1S2)						
% (Within Group)	43.4	56.5	65.2	34.7	91.3	8.6
% (Within Sample)	20.4	26.5	30.6	16.3	42.8	4.0
Moderate (S3)						
% (Within Group)	47.3	52.6	52.6	47.3	78.9	21.0
% (Within Sample)	18.4	20.4	20.4	18.3	30.6	8.1
Poor (S4 S5)						
% (Within Group)	14.3	85.7	14.3	85.7	28.6	71.4
% (Within Sample)	2.2	12.2	2.2	12.2	4.0	10.2

P. M. E. K.Pathiraja, K. V. N. N.Jayalath, and S. D. J. N. Subasinghe

Research Project 2: Effect of Land Size on Productivity of Coconut Lands in Sri Lanka: An Empirical Estimation

The latest agricultural census in 2002 has revealed that the total land extent under estate sector has reduced from 103 129 ha in 1982 to 71 347 ha in 2002 while the smallholdings sector has increased from 313 124 ha to 323 489 ha during the same period. The extent under small holdings is 81.9% of the total coconut land extent. Even though the extent under coconuts has been decreased, the national production of coconuts has shown slightly increasing trend during this period indicating increase in productivity of existing coconut lands. Theoretically large farms are more productive than small farms due to economics of scale but there is a general belief among coconut growers that the small lands show higher productivity than estates. Even though, there is limited research evidences to prove this in Sri Lanka it is well evident in the international literature that there is an inverse relationship between farm size and productivity (output per unit area of land) in agriculture.

The analysis was done using cross section individual farm level data in major coconut growing areas, namely Kurunegala, Puttalam and Gampaha. The primary data collected for the cost of production survey conducted by the CRI was used for the analysis.

The level of productivity of each cultivation was plotted against the size of the land as shown in Figure 2, where the respondents (n=69) were arranged in ascending order by taking into account of land size. It shows that the productivity of coconut lands tend to decrease (i.e. negative trend) as the land size increases. The Pearson Correlation Analysis between productivity and land size was -0.513 and significant at 5% significant level.

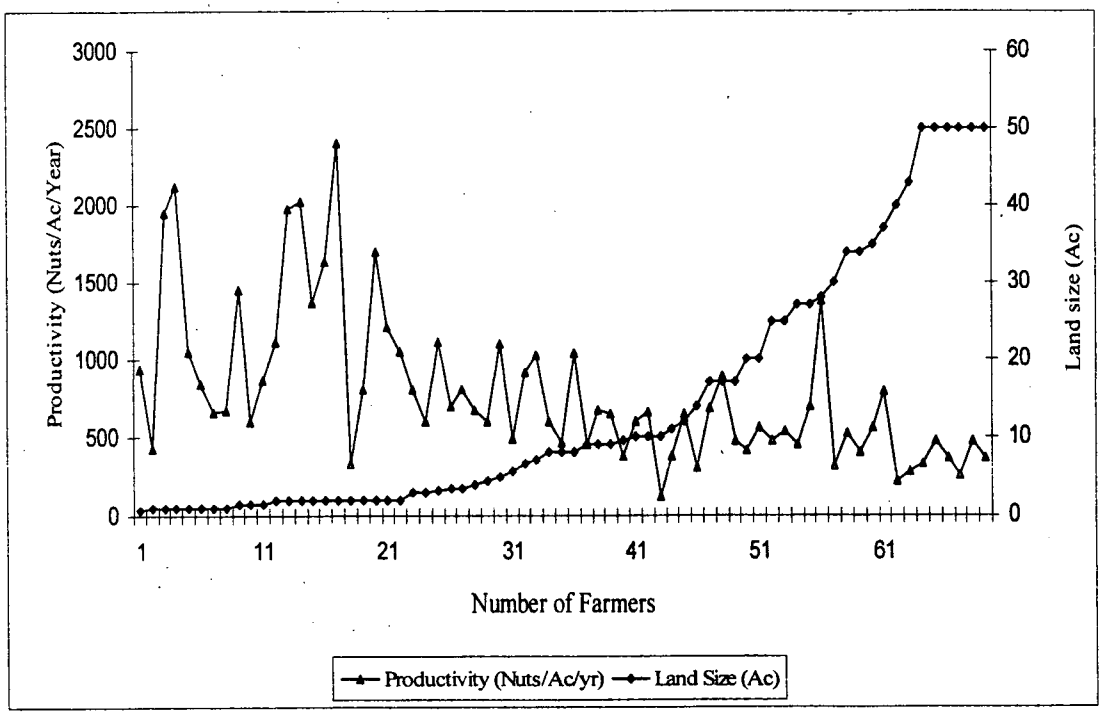

Figure 2: Variation in Productivity vs Land Size

The estimated productivity was highest in the home gardens (Figure 3) and it was 3 38 nuts/ac/year. The average productivity was 2 954 nuts/ac/year in home gardens. The lowest productivity of 1 052 nuts/ac/year was achieved at the land size of 21 ac. The average productivity of smallholding sector was 2 075 nuts/ac/year. When land size was increased beyond 21 acres the productivity started increasing again. The average productivity of estates was 1 094 nuts/ha/year. Figure 3 shows that productivity was decreasing again in the estate sector but the available data is not adequate to confirm this.

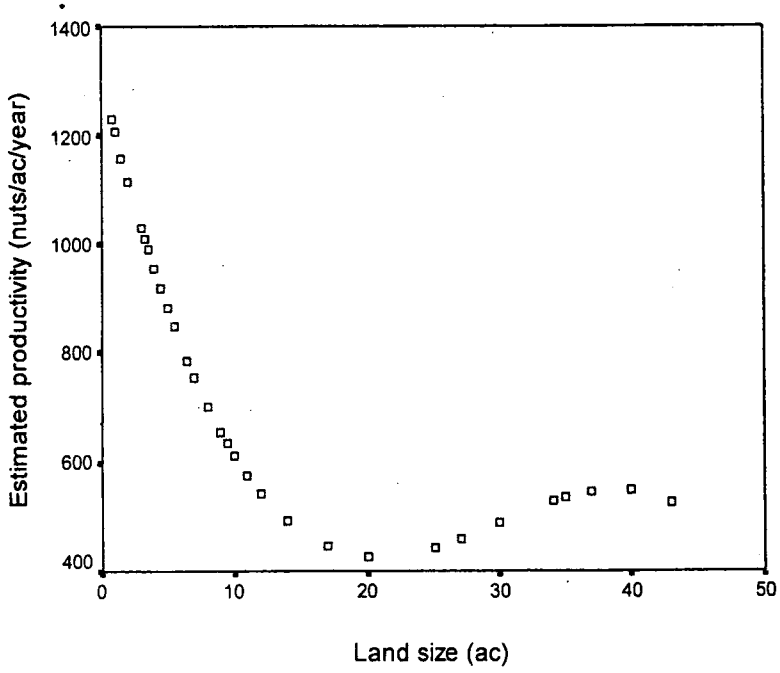

Figure 3: Variation of estimated production vs land size

Among other variables included in the model and only the variable labor was significant. The usage of labor was highest in home gardens. It was 29 man days/ac/year. The usage of labor in smallholdings and estates were lower than home gardens.

Absentee landlordism is very common in the estate sector of coconuts. The owners have little direct relationship with the land and their main source of income is occupations. Therefore this undervalues the merits of the coconut estate as a productive resource. Labor commitment in smaller farms is more than large farms, due to the existence of a dual labor market. It is also evident that family farms are more efficient and superior to other types of farming. The family farm is operated by the owner and the family provides the large bulk of the regular labor requirements through out the year. Hired labor is also used in family farms. Since the family members work with hired labor the work can be monitored well. This does not happen in large estates. The reduction in labor usage as the farm size increases well document in international literature. Smaller farms use more inputs as fertilizer per acre. The dependency on hired labor is higher in estate sector. The hired labor has to be paid at market rate. Family laborers work in their own lands at a wage of less than market rate. The imputed price of labor to the smaller farm is lower than that to the large farm and hence farmer uses more labor per ha. Intensive care and more input usage have increased the productivity of home gardens. When the land size is increased in the small holding sector input usage is decreased because of managerial problems. The productivity has increased when it comes to the estate sector because they are capable of using hired labor and use more inputs as fertilizer.

Based on the analysis of primary data it was found that the productivity of coconut lands significantly depends on the land size of the holding. The empirical results of the study showed the land size and the labor are the significant factors that determine the productivity of coconut lands. The productivity is decreasing with the increase of land size within the smallholding sector. One of the major reasons behind this phenomenon may be non-availability of and/or inability to hire required amount of labor to manage these smallholdings productively with all recommended practices as returns on the investment low. However the results highlight that the productivity of coconut estates increases as the land size increases in general, but at a lower rate. While the labor was having a significant impact on this behavior, none of the other variables show any significant impact. The descriptive statistics derived from the first hand information obtained from 69 coconut growers in the sample show that they are not much concerned about adopting these practices in their cultivations.

The results emphasize the importance of securing (without fragmenting) large scale estate sector since it shows the high production as well as the increase in productivity, from one hand, and promotion of coconut cultivation amongst the smallholdings sector and specially within the home gardens, as they were proven to be the highest productive in this respect. In a situation where the majority of coconut lands in the country belong to the smallholding sector and having understood the importance of estate sector, the regulatory agencies governing coconut industry in Sri Lanka may develop sets of two alternative policies for these two sectors (i.e. smallholding and estate) with respect to fragmentation of lands. For example, fragmentation of estates should not be allowed unless it is strongly justifiable as it has direct impact on total coconut production in the country. However, to make the agricultural and land policies to be realistic, fragmentation of smallholdings may be allowed case by case basis by taking into account of the need, however, every effort must be taken to keep those fragmented lands under coconuts, may be under different ownership.

A difference was not significant in variables of land suitability class and agro-ecological region because most of the holdings were in land suitability class S_3 and S_4. This is a limitation of the study and can be improved by using stratified sampling instead of random sampling.

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Research Project 3: Quest for Better Technology: Case of Brown Coir Fibre Industry in Sri Lanka

The objective of this study was to assess the impact of a number of attributes (a = 23) explaining 5 major factors (Labor, Land and Capital, Machine, Technical and Market) that influence a selection of a particular technology to manufacture brown coir fibre in Sri Lanka (i.e. Sri Lankan Drum Pairs, Defibering Machine, D1 Machine). The millers perceptions towards a number of attributes explaining the appropriateness of these three technologies to extract brown coir fibre can be classified into five subsets, including: (a) Labor; (b) Land and Capital; (c) Machine; (d) Technical, and (e) Market (Table 2).

Table 2. Attributes explaining the appropriateness of a coir fiber extraction technology

Subsets	Attributes
1. Labor	1.1 Number of labors required to operate the machine
	1.2 Skilled labor requirement
	1.3 Safety for labors
	1.4 Labor willingness to work
	1.5 Labor efficiency in each technology
2. Land and Capital	2.1 Land area needed for the technology
	2.2 Initial capital
	2.3 Subsidies available
	2.4 Credit scheme
3. Machine	3.1 Power consumption
	3.2 Machine efficiency
	3.3 Productivity
	3.4 Product quality
	3.5 Husk soaking period
	3.6 Husk rejection rate
	3.7 By-product quantity
4. Technical	4.1 Technical assistance for installation
	4.2 Technical assistance for repair and maintenance
	4.3 Repair and maintenance
	4.4 Availability of spare parts
	4.5 Frequency of repair
5. Market	5.1 Market demand
	5.2 Market price

A cross section of coir fiber mills located in the Coconut Triangle of Sri Lanka (Kurunegala, Gampaha, and Puttalam districts) (n = 30) were selected to collect data. Personal interviews with the owner of the mill were carried out with the help of a structured questionnaire from May to July, 2008. A pilot testing was done by visiting several sites to confirm the issues listed as

attributes. To evaluate extent to which an owner of a mill agree with the phenomenon explained in each attribute classified to these five subsets, every statement was set to a seven point bipolar scale ranging from (+3) "extremely good" to (-3) "extremely bad". The scores given by respondents' (mill owner) on these statements (n=23) were examined using the Semantic Differential Analysis (SD) techniques.

The all five attributes considered under labor subset gained the lowest perception of coir millers with regard to Sri Lankan Drum Pair technology (Figure 4). Skilled labor requirement is highest for the Sri Lankan Drum Pair and lowest for the D1 Machine. Scarcity of skilled labor has compelled the miller to shift to other technologies. Millers' perception for safety of workers is highest towards the D1 Machine while lowest for Sri Lankan Drum Pair. The special feature of Defibering and D1 Machine is that the operations of these machines are gender indiscriminate.

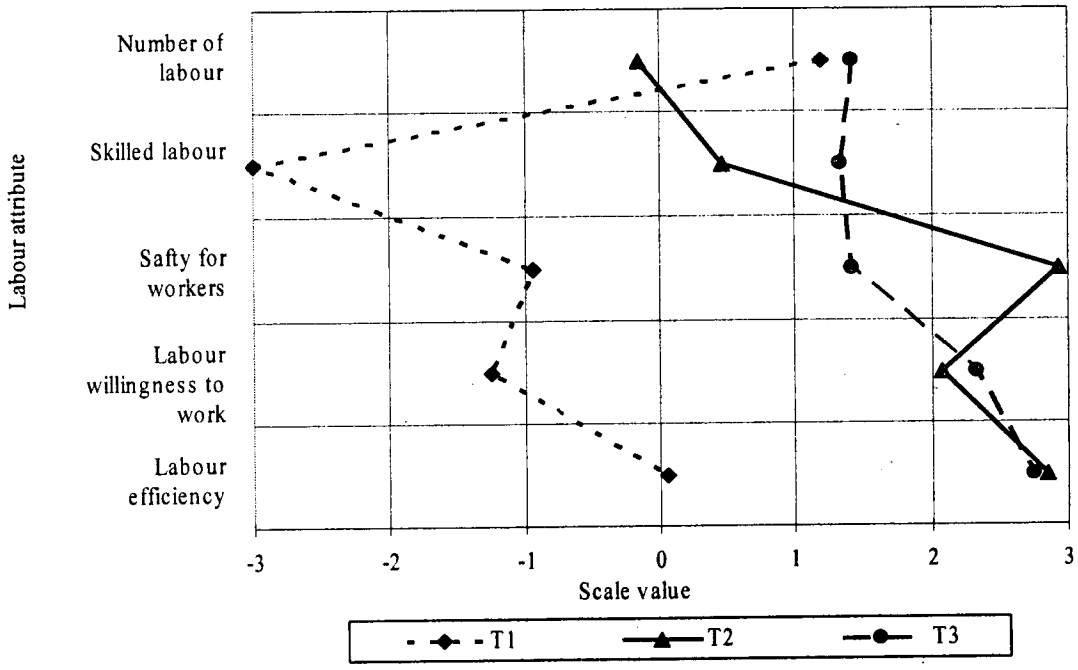

Figure 4. Semantic differential chart for labor subset in brown coir fiber extraction technologies

The D1 Machine requires less land area (Figure 5) than other two technologies because of the compact nature of the machine. Initial capital is lowest for the Sri Lankan Drum Pair as it is fabricated locally. On the other hand initial capital requirement is highest for Defibering Machine since it was imported from India. Subsidies and credit facilities are hardly available for coir fibre millers. This is one of the major reasons for coir fibre millers to adopt less effective existing technologies rather than shifting to new technology which require higher capital investment.

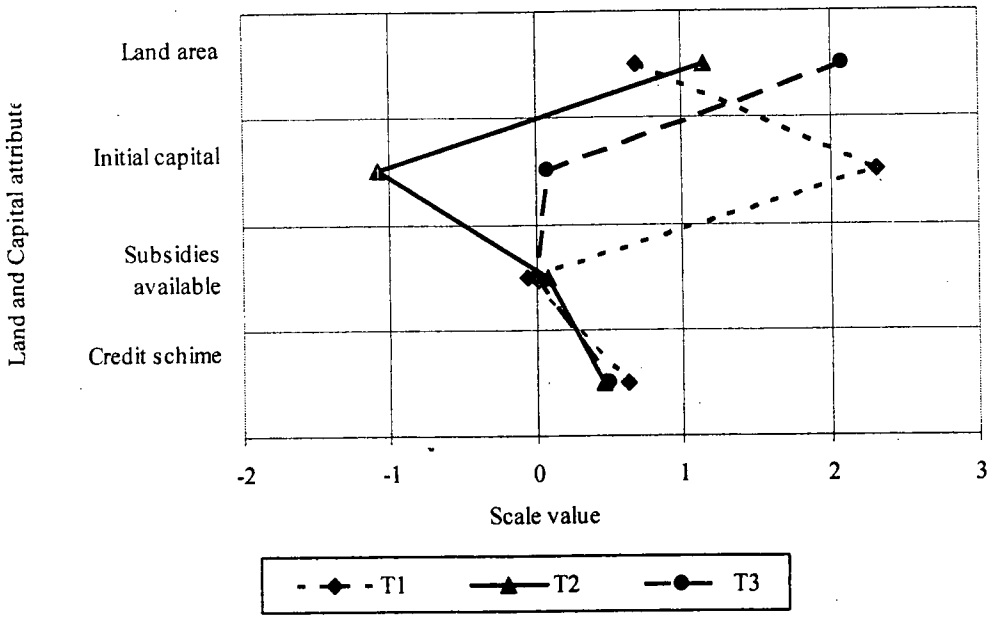

Figure 5: Semantic differential chart for land and capital subset in brown coir fiber extraction technologies

Among machinery characteristics on technology (Figure 6), millers are in favor of Sri Lankan Drum Pair for its low power consumption and high product quality. However, millers are the view that productivity of Sri Lankan Drum Pair is the lowest among these three technologies. The productivity and machine efficiency was highest in Defibering Machine. Even though the Defibering Machine extract bristle fibre, its' quality in terms of length and strength is far behind that of extracted from Sri Lankan Drum Pair. This is the reason for coir fibre millers to use Sri Lankan Drum Pair for bristle fibre extraction irrespective of its low productivity. The husk rejection rate is also higher in Sri Lankan Drum Pair technology than other two technologies. Inability to use small sized husks and husks damaged by mite infestation for fibre extraction in Sri Lankan Drum Pair technology results in a higher rate of husk rejection.

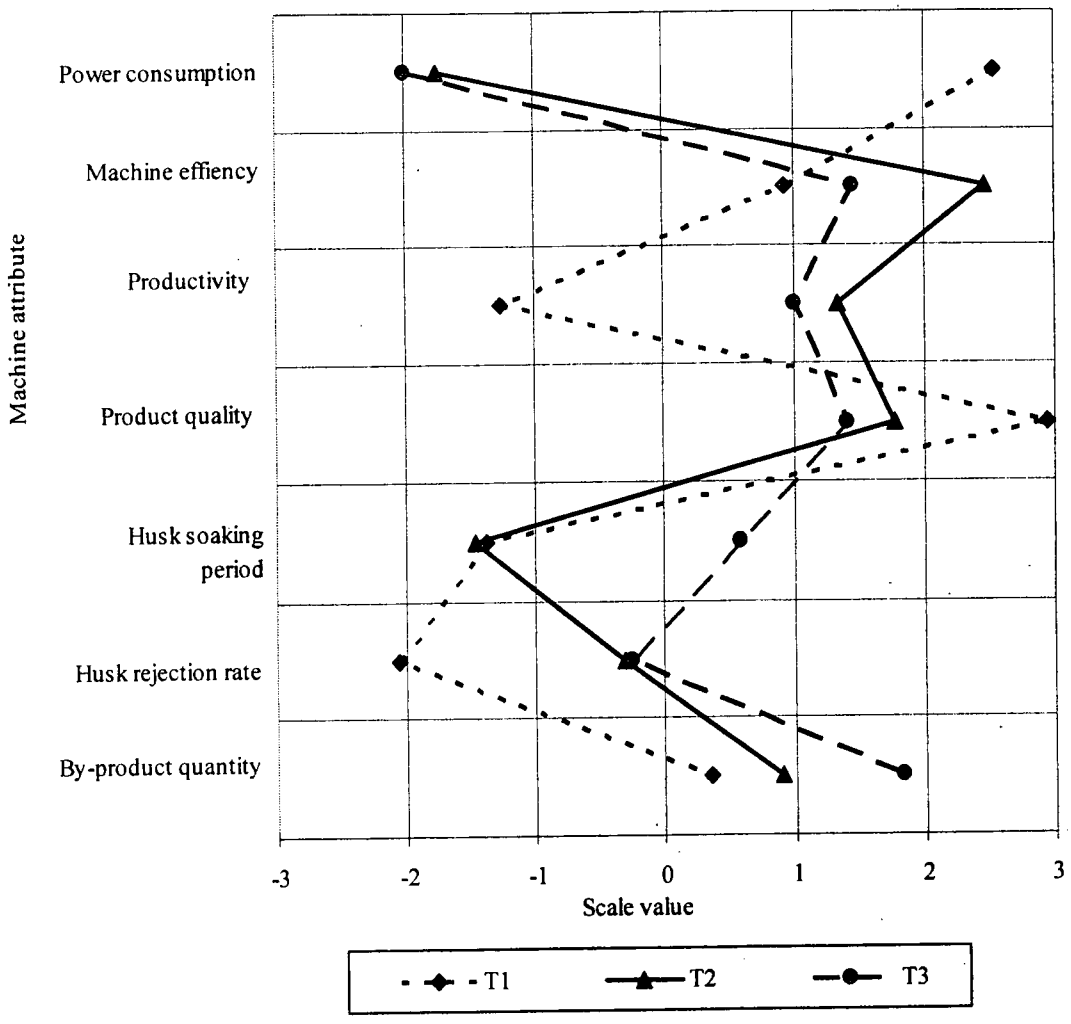

Figure 6 : Semantic differential chart for machine subset in brown coir fiber extraction technologies

The semantic differential chart for technical subset (Figure 7) showed that Sri Lankan Drum Pair achieved the highest respondent's perception for all the attributes except frequency of repairs with scale value closer to three (extremely good). This is because the machine is locally fabricated hence installation and maintenance of the machine is comparatively easier. Defibering Machine had the lowest miller's perception for every technical attribute. Although there are some advantages of Defibering Machine over Sri Lankan Drum Pair machine, millers had re - shifted to Sri Lankan Drum Pair machine due to its technical attributes.

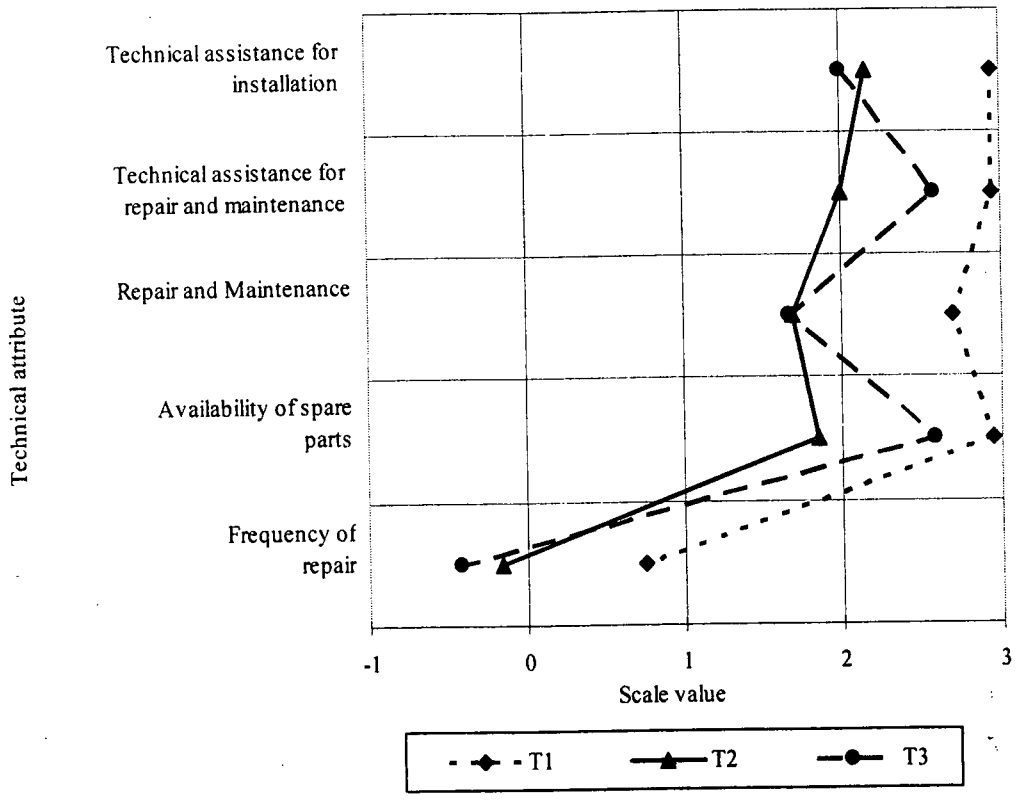

Figure 7. Semantic Differential chart for technical subset in brown coir fiber extraction technologies

Semantic differential chart for market subset (Figure 8) showed that Sri Lankan Drum Pair machine had the highest respondents' perception for both market demand and marked price of the product. Brown fiber trade is dominated by Sri Lanka because of this unique quality of the bristle fibre extracted from Sri Lankan Drum Pairs. D1 Machine had the lowest perception for these two attributes among three technologies. However, fiber extracted from D1 Machine also had good demand and it is indicated by the average scale value closer to two (moderately good).

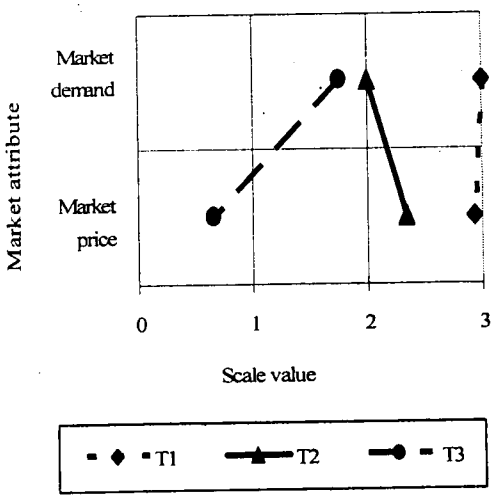

Figure 8. Semantic differential chart for market subset in brown coir fiber extraction technologies

Image comparison of three technologies

In labor attribute, (Table 3) only the Sri Lankan Drum Pair had negative image, other two machines had positive image. All the three technologies had negative image for land and capital attributes and machine attributes. Technical and market attributes had positive image for all the technologies.

Table 3. Millers' image on three different brown coir fiber extraction technologies

Machinery Attributes	Sri Lankan Drum Pair	Defibering Machine	D1 Machine
Labor	-	+	+
Land, and Capital	-	-	-
Machine	-	-	-
Technical	+	+	+
Market	+	+	+

Note: Scale value greater than or equal to one (slightly good) had been marked as plus (+) and other was negative (-).

This study emphasized on the coir fiber millers' perception on technology adoption which is an important source of information for further technological improvement.

Although, Sri Lankan Drum Pair technology was negatively perceived by millers regarding labor subset, superior quality of bristle fibre extracted from it could not be gained from any other technologies. Hence, millers are reluctant to shift from this technology. Productivity achieved by Sri Lankan Drum Pair technology is not at a satisfactory level. According to millers view, low productivity increases production cost and reduces profit margin. Therefore, introduction of an improved technology to overcome the issues related to labor and low productivity of Sri Lankan Drum Pair technology is important.

Initial capital is one of the major obstacles for millers when they are shifting to another technology. However, financial supporting system in the coir fibre industry is lacking. Therefore, there is a need of government intervention to introduce credit systems to provide financial support to motivate millers to shift to new technology and improve future prospect of this industry.

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Area of Research 2: ECONOMICS OF TECHNICAL RECOMMENDATIONS OF THE CRI

Research Project 1: An ex-post Evaluation of Adoption of Virgin Coconut Oil Expeller Technology in Sri Lanka

Virgin Coconut Oil (VCO) is an emerging product in the world market has due to its nutritional and health benefits and applicability as a beauty product. It has a higher demand in international market over the traditional coconut oil. Industry level VCO production has been started in Sri Lanka in 2004. CRI developed a VCO producing technology and disseminates to entrepreneurs at a concessionary price. It comprises of VCO expeller, cutter, drier, and oil filter. The VCO extraction method is called "Cold extraction method". Since then CRI has disseminated this technology for 12 entrepreneurs and only eight firms are operating at present. CRI states their recommendations for the expeller but, the level of their realization of these recommendations

was not yet analyzed and for further improvements of the expeller, it is necessary to get the customers' feedback. Hence this study was conducted to find out the level of realization of the recommendations for the expeller machine and to further analyze the level of customer satisfaction of each customer.

The level of realization was assessed using descriptive statistics. Customer satisfaction on the expeller was measured considering 15 attributes of the machine. A five point likert scale was used for the analysis. A satisfaction index was formulated to find out the level of satisfaction for each attribute.

$$SI_i = \frac{\sum_{i=1}^{n} F}{n}$$

SI_i = Satisfaction Index of the "i"th attribute
F = Satisfaction level of each producer
i = Attribute
n = Number of producers

According to the realization of CRI recommendations TRAIN (No need to have a special training), ACCID (Minimum chance of accidents taking place), MOIST (Machine is sensitive for the moisture content of the sample PSIZE (Particle size of the sample affects on the performance of the machine) and TEMPP (Temperature of the product ranges from 55-60°C) obtained 100% realization. The mean value of the percentage of realization of recommendations was 72.5 % and there were four statements below the mean value. Among them, WORKS (Two workers are needed to operate the machine) and SUPPS (Two supporters are needed to operate the machine) had obtained zero percent adoption. In the case of these two statements, it implies that the labour requirement is quite low compared to the recommended level and it can be considered as a plus point for this technology as it will minimize the labour cost (see Figure 9).

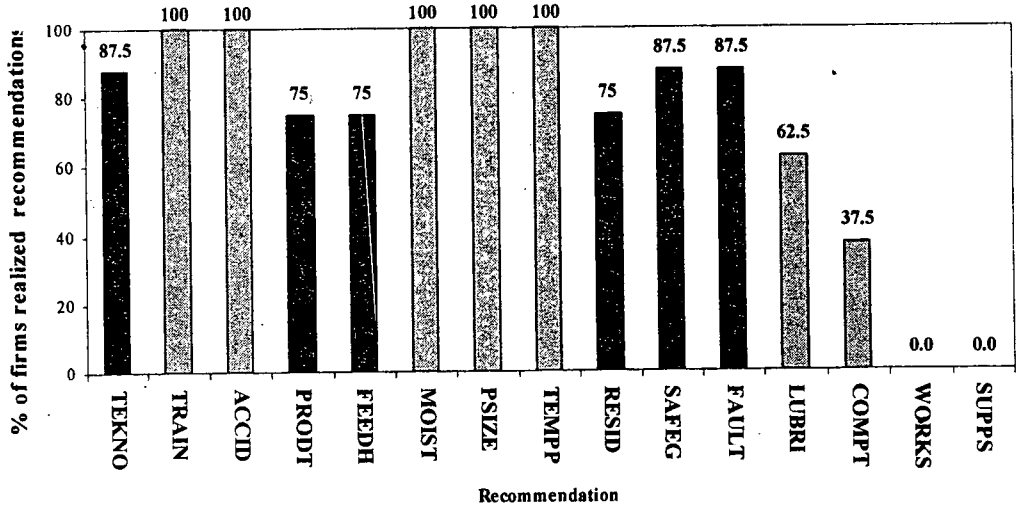

Figure 9: Firms' realization of the recommendation

The results showed that out of the eight firms four firms were in satisfied (ST) while the other four firms were in highly satisfied category (HNS) (Table 4). No firms were included in the indifferent (ID), not satisfied (NS) or highly not satisfied (HNS) categories.

Table 4. Categorization of firms based on scale value

Scale value	Category	No of firms
15-27	HNS	0
28-39	NS	0
40-51	ID	0
52-63	ST	4
64-75	HS	4

Results showed that four firms were in "satisfied" group while other four firms were in "highly satisfied" group. "Environmental pollution" was the attribute with higher satisfaction index value while the "price of the machine" was the lowest among them. The expected and observed levels of satisfaction showed a gap for all the attributes as a whole. Thus, as the technology disseminator for this group CRI should emphasize more on the attributes which their clients had showed a lower level of satisfaction.

Compared to the observed mean (0.98) of the index, there were five attributes below the mean namely; RESID (Re-salability of the residue), SPAPA (Availability of spare parts), PRICE (Price of the machine), SEFEG (Automated safeguard) and POWER (Power consumption of the machine) (Figure 10). Therefore, these attributes should be considered for further improvements.

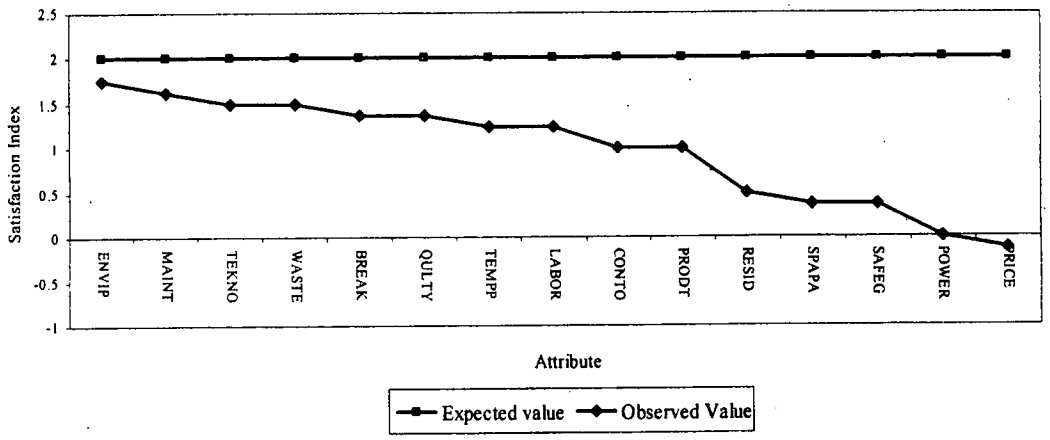

Figure 10: The gap between the expected and realized satisfaction for each attribute

They suggested improving the feeding system by introducing an auto feeding system. Some of them emphasized the need of an emergency stopping device for the machine to ensure the safety. For the oil extraction technology, one entrepreneur suggested to adopt a centrifuge system. Marketing of the product was a challenge for some of the firms operating in local VCO industry. Among all the firms surveyed, only two firms had exported their products directly to the international markets, while three firms sold the product to intermediate exporters. The price of 1 liter of VCO in international market should be at least 5$ for this industry to be rewarding. Organic VCO yields a premium but the high cost and the availability of organic coconut is a drawback. Therefore, the producers should be supported by the relevant authorities in capturing markets.

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Area of Research 3: ECONOMIC STUDIES ON PRODUCTION OF COCONUTS

Research Project 4: Production and Cost of Production of Coconuts and Major Coconut Products at Provincial Level

In par with preliminary cost of production survey conducted in 2007, an expanded survey was started to calculate the cost of production of fresh coconut, coconut oil and desiccated coconut in coconut triangle which is important in calculating provincial/regional GDP. A book on collecting necessary information (Farm Record Book) was distributed among coconut growers and stratified sampling was used. The collection of data from these growers was continued during the year.

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Consultant Agricultural Economist

Dr. J. M. U. K. Jayasinghe, Head, Department of Agribusiness Management, Faculty of Agriculture & Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila provided his service as the Consultant Agricultural Economist at the Division.

REPORT OF THE TECHNOLOGY TRANSFER DIVISION

Head-P A H Nimal Appuhamy, MSc.

1. GENERAL

During the year under review, the Technology Transfer Division expanded its activities further to ensure effective dissemination of technologies and information to coconut growers and other stakeholders. Main strategies of the division we are the dissemination of coconut cultivation and processing technologies, to extension personnel, growers, commercial entrepreneurs the general public, and the acquirsiha of information about technology needs, production problems and adoption of technologies. In addition the evaluation of the relevance, effectiveness, impact, and affordability of technologies are another major activity of the division. With the implementation of extensive awareness programmes to manage Weligama Coconut Leaf Wilt and Leaf Rot Diseases the division focused more on the publicity and awareness programmes. With the implementation of extensive management programme to Weligama Coconut Leaf Wilt Disease (WCLWD) and leaf rot diseases divisions gave more emphasis conduct awareness programmes they print and electronic media to give wide publicity about the disease. Several awareness programmes were conducted in the Matara, Galle and Hambantota Districts in collaboration with CCB for Coconut Development Officers, Village Level Officers, Grama Niladaries, school children and Police Officers. The number of growers who obtained the services of the Institute has shown a significant increase during the year. Studies were also conducted to evaluate the relevance, effectiveness, impact and affordability of technologies.

2. OTHER ACTIVITIES

2.1. Mr. H C Herath, Extension Officer, is continuing his PhD programme at the Tomas Bata University in Zlin, The Czech Republic since in December 2007.

3. COLLABORATIVE ACTIVITIES WITH CCB

3.1. An educational and training programme was conducted for newly recruited Coconut Development Officers of CCB at the CRI from 08 – 18 January. The division also conducted several collaborative programmes to educate and update technical knowledge of the extension field staff of CCB on new technologies and to identify technology needs and related problems faced by coconut growers in different areas.

3.2 In collaboration with CCB, the division conducted several awareness programmes for Coconut Development Officers in Matara, Galle and Hambantota districts. In addition, field level training programmes were also conducted for political and administrative authorities, KRUPANISA officers, Agricultural Instructors, Grama Niladaries, Samurdi Officers in the Matara, Hambantota and Galle districts.

3.3. Two awareness programmes were conducted for inspectors of police stations about the management of coconut leaf wilt disease and their role in check points established in the border areas in Matara and Galle districts on 23 August in collaboration with CCB.

3.4. A technical meeting was held with the Coconut Development Officers at the Regional Office at Kurunegala with the officials from the CCB head office on 04 August.

3.5. Awareness programmes on the management of Weligama Leaf Wilt and leaf rot diseases for relevant field officers, coconut growers and school children in three districts were conducted in the boarder areas in August with the staff of CCB.

3.6. A full day educational programme was conducted at CRI for a group of 19 Coconut Development Officers from the Kurunegala Region on 10 October on the coconut based products.

4. TRAINING OF TRAINERS PROGRAMMES

Several educational programmes were conducted by the Division to enhance the technical capabilities of field level trainers and extension personnel attached to different organizations, who provide advisory services to small holder sector coconut growers. Several and training programmes were conducted for the private sector institutions which involves in the promotion of coconut based agricultural development activities.

4.1 Eight programmes were conducted for Agricultural Development and Research Assistants *(KRUPANISA)* and Divisional Development Officers (DOO) in the Hambantota District at Middeniya Research Station on 15 and 16 May, 12 and 13 June, 14 and 15 August and 18 and 19 September. They were provided with advisory circulars and training tools such as flash cards and CDs with video documentaries. Nearly 175 officers were trained under these programmes.

4.2 A full day educational programme was conducted for the officials and management staff of LJM Peries and Company at the CRI on the management of coconut plantations on 12 January. Twenty five officers participated for the prgramme.

5. EDUCATIONAL PROGRAMMES FOR COCONUT GROWERS, MANAGEMENT STAFF OF COCONUT ESTATES AND SMALL ENTREPRENEURS

5.1 One day educational programme - In order to maintain a close interaction among the researchers and the coconut growers and management staff of coconut estates the most popular one day educational programme series was conducted in this year too. This series was designed to fulfill the knowledge needs of coconut growers and to have direct interaction with researchers in various disciplines. This series includes seven one-day programmes on specific subject areas. At the beginning of the year, complete year schedule was advertised in newspapers requesting interested coconut growers to register. Based on different subject categories coconut growers have the choice to select the subjects. According to the subject areas, these programmes were held in different substations of the Institute facilitating to conduct field demonstrations. 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 were as follows.

- The first programme of the series was conducted on 29 May at the Isolated Seed Garden, Ambakelle on " *Replanting and Underplanting of Coconut*" with the participation of 246 coconut growers.

- The second programme of the series was conducted at Ratmalagara Estate on 27 June on "*Soil and Moisture Conservation Measures and Irrigation for Coconut*" with the participation of 230 coconut growers.

- The third programme was conducted at the Bandirippuwa Estate on 25 July on " *Organic and Inorganic Fertilizer Application for Coconut"* with the participation of 250 coconut growers.

- The forth programme was conducted at the Walpita Reasarch Station on 29 August on *" Intercropping in Coconut Lands"* with the participation of 235 coconut growers.

- The fifth programme was conducted at the Bandirippuwa Estate on 26 September on " *Coconut Pests and Disease Management*" with the participation of 230 coconut growers.

- The sixth programme was conducted Ratmalagara Estate on 24 October 2006 on " *Rehabilitation of Low Yielding Coconut*" with the participation of 250 coconut growers.

- The seventh programme was conducted at the Bandirippuwa Estate on 28 November on *" Coconut Estate Management"* with the participation of 255 coconut growers.

At the end of this programme series, certificates were awarded to those who participated in all seven programmes.

5.2 Trainings on coconut based products for small scale Entrepreneurs.

5.2.1 A programme on coconut based products was conducted at the Vidatha Centre at Mahawa on 22 May for a group of 25 entrepreneurs.

5.2.2 A Training programme on coconut based products was conducted for a group of 30 women from the AGA division, Dankotuwa on 30 April.

5.2.3 A training programme was conducted for a group of 15 women on coconut based products at the AGA office, Wennappuwa on 26 May.
5.2.4 A full day training programme on coconut based products was conducted at the AGA division at Nattandiya for group of 32 women on 25 June.

5.2.5 One day training programme on coconut based products was conducted at the Kandana Vidatha Centre for a group of 37 small scale entrepreneurs on 07 July.

5.2.6 On the request of the Vidatha Center at Wariyapola, one day propgramme was conducted for a group of 44 coconut growers and small scale entrepreneurs on 14 July.

5.2.7. A training programme on coconut based products was conducted at the AGA division at Mirrigama for group of 32 women on 21 July.

5.2.8 A training programme was conducted on coconut products on 22 September at the Vidatha Centre at Mallawapitiya for a group of 40 coconut growers and women entrepreneurs.

5.2.9 On the request made by the Vidatha Center at Ja-Ela/ Wattala a training programme was conducted on 29 September for a group of growers and entrepreneurs.

6. ADVISORY FIELD VISITS ON SPECIFIC PROBLEMS

The institute receives a large number of requests from coconut growers to inspect their plantations and provide necessary advice for their field problems from almost all the coconut growing areas. Most of these requests are referred to CCB regional manager for necessary assistance.

During the year about 30 such requests were referred to relevant regional managers. But very specific problems and problems which cannot be attended by the CCB personnel were referred to us for inspection. The divisional staff inspected these plantations and provides necessary advice and guidance. During the year 35 advisory visits were made on special requests and reports were submitted with necessary recommendations.

7. FIELD DAYS, SEMINARS/ WORKSHOPS

7.1 A full day seminar was conducted at CRI on 14 February for a group of 45 coconut growers who supply organic coconut to the *Serandipol* Company at Kuliyapitiya.

7.2 One day seminar was conducted for the managers and workers of estates managed by the Chilaw Bishop House on 26 March.

7.3 A seminar was conducted for the members of the Coconut Growers Association of Sri Lanka at the Marawila Sport Club on 08 October.

7.4 A three day educational programme was conducted on 13, 14, and 16 October, at CRI for a group of 40 students from the Kuliyapitiya and Beliatta Technical Schools.

7.5 A full day seminar was conducted at Matara regarding the management of Weligama Coconut Leaf Wilt disease for the members of the Coconut Growers Association of Sri Lanka.

7.6 Arrangements were made to obtain the services of a mobile media vehicle of the Department of Agriculture from 30 June to 12 July to conduct educational programmes regarding the management of Weligama Wilt disease.

7.7 A full day seminar was conducted at the CRI for the members of the Coconut Growers Association of Sri Lanka on 06 December.

8. EDUCATIONAL AND FAMILIARIZATION PROGRAMMES FOR STUDENTS AND TEACHERS

8.1 During the year, educational programmes were conducted at the institute for 5600 students and teachers who visited CRI from 45 schools.

8.2 Special service was provided to guide the students for the preparation of their GCE O/Level and A/Level projects on coconut related fields. The division provided necessary guidance for 55 students visited the institute and posted the required information to 35 student projects.

8.3 A full day educational programme was conducted for a group of undergraduates from the University of Kelaniya on 28 May.

8.4 A training programme was conducted for a group of growers who are interested in the preparation of compost at the Research Station at Makandura on 23 July. Thirty coconut growers participated in this programme.

8.5 A four months attachment training programmes was conducted for seven agriculture diploma students from the School of Agriculture, Kundasale and NAITA.

8.6 A full day educational programme was conducted for agriculture diploma students from Angunakolapelessa on 18 November.

9. FARMER PARTICIPATORY FIELD PROGRAMMES

9.1 Farmer Field School (FFS) is a new technology transfer tool suitable for the small coconut holding sector. FFS were conducted successfully in various coconut growing areas. These programmes were conducted in collaboration with the regional field staff of CCB.

During the year the following FFS programmes were conducted

a. Seven programmes were conducted with the Kuliyapitiya farmer group on 10 January, 21 February, 03 April, 23 May, 22 July, 12 August, 16 September, 11 November and 08 December covering the all technical areas required by the small holders.

b. One programme was conducted at Ratgama on 04 March

c. Five programmes were conducted with farmer group at Middeniya on 15 May and 11 June, 18 July, 14 August, 11 September covering the area specific needs of coconut small holders.

9.2 The farmer participatory field demonstration programme commenced in 2007 to promote the use of organic manure in coconut plantations to improve the nutrientiant status of coconut growing soils was continued. Five acre demonstration sites located at the road side of interested growers were selected for this programme. Based on the soil type, coconut plantation, and the availability of organic materials suitable organic based packages will be recommended for implementation. Land owners are expected to implement recommended organic packages according to the instruction given by the Institute. Out of the 15 sites selected only six sites have completed the adoption of recommended practices. Few more interested growers have been selected for this demonstration programme and their estates have selected.

10. RESEARCH AND DEVELOPMENT WORKS

10.1 Mr. A M A P G Gunawardana, Senior Extension officer conducted a study to assess the credibility of different agricultural information sources and channels and to study the constraints being perceived by coconut growers in agricultural information seeking. The study was conducted in two CDO ranges in the Kurunegala District. According to the results, neighbors of coconut growers and the Agricultural Development, Research and Production Assistant (KRUPANISA) were the most effective agricultural information sources of coconut growers in the Kurunegala District. It was also reveled that the Agrarian Services Center was the most effective center for agricultural information for coconut growers. Out of the media sources television was found to be the most effective impersonal agriculture information channel. Lack of agricultural magazines, newspaper articles and advisory circulars was found to be main constraints that coconut growers who are the seeking agricultural informed.

10. PRINTING AND PUBLICATIONS

10.1 The technical journal of the institute COCOS Vol. 18, 2007 was published.

10.2 Seven booklets were issued as supportive materials for the participants of one day educational programme series.

10.3 Two issues of the Coconut Technology Update were published. This publication was introduced to disseminate information on new technological development within a short period of time. This is issued once in every four months in two languages.

10.4 A new series of advisory bulletins was introduced in an attractive colour format with detailed information on specific subject areas. During the year the following advisory bulletins were issued; Fertilizer Application for Coconut and Land Suitability, Pests and Diseases of Coconut, and Coconut Based Products.

10.5 The following publications and media materials were produced and issued for the educational and awareness programmes to manage the Weligama Coconut Leaf Wild and Leaf Rot Diseases in the Southern Province.

a. A colour poster was prepared and printed 10,000 copies with a map of affected areas and the declared boarder including warning massages regarding the transportation of coconut and planting materials. These posters were distributed among the all CCB regional offices.
b. A booklet giving guidelines and recommendations on the management of both diseases was published in Sinhala (3000 copies) and English (1000 copies) languages. These were distributed to trainers and officials involved in the management of the diseases.
c. Two sets of books in triplicate which are required for issuing permits and orders to remove affected palms in the boarder areas were printed in 50 copies each and issued them to the Project office at Matara.
d. Ten digital boards of 4' x 6' with warning signs to stop transportation of coconut, coconut seedlings and other palms from the affected areas. These boards were fixed at the police check points along the boarder areas.
e. Half page colour newspaper advertisement was published in weekend and daily newspapers. It was published in Daily News, Dinamina, Divaina and Sunday Lankadeepa.

12. PARTICIPATION IN PUBLIC AND AGRICULTURAL EXHIBITIONS

The division participates and prepares attractive exhibition stalls in public and agricultural exhibitions to promote cultivation and processing technologies

12.1 The Institute participated at the Janatha Sathkara Sevaya at Trincokomale on 19 and 20 January.

12.2 An exhibition stall was put up at the Deyata Kirula exhibition at BMICH from 04 to 09 February.

12.3 An exhibition stall was also put up at the exhibition at Dankotuwa Balika Vidyalaya from 01 to 03 February

12.4 The Institute also participated at the Janatha Sathkara Sevaya exhibition held at Ampara from 23 to 24 February.

12.5 The Institute had a stall at the agricultural exhibition at Baddegama organized by the Agriculture Development and Agrarian Services from 03 to 05 April.

12.6 The Institute participated at the Industrial and Machinery Exhibition held at the BMICH from 15 to 18 May.

12.7 The Institute had an exhibition stall at the agricultural exhibition to commemorate 60 years of higher education in agriculture of the Faculty of Agriculture, University of Peradeniya from 08 to 12 October, 2008.

12.8 The Institute participated at the educational exhibition at the Sri Darmaloka Collage, Kelaniya from 23 to 25 October.

12.9 The Institute participated the exhibition organized by the University of Wayamba, Makandura, from 28 to 29 October, 2008.

12.10 A stall was prepared at the Gangasiri Udanaya exhibition held at Gampola from 24 to 30 December 2008.

13. AUDIO VISUAL AND MEDIA MATERIAL PRODUCTION AND MASS MEDIA PROGRAMMES

13.1 **Interactive Multimedia CDROM (IMM CD ROM)**

The Interactive Multimedia CDROM developed by CRI ("*Pol Wagawa 1*") in collaboration with the Audio Visual Centre of the Department of Agriculture was in high demand. The **IMM CD ROM** is a mixture of media elements like sound, graphics, photos, illustrations, video, animation and text. It requires computer based operations for delivery of information. The first Interactive Multimedia CDROM produced and resembles to an electronic hand book on coconut cultivation and management. The second Interactive Multimedia CDROM on coconut based products is being produced in collaboration with the Audio Visual Centre, Gannoruwa.

13.2 **Video Documentaries on recommended management practices**

The video documentaries produced by the division on coconut cultivation and management technologies were in high demand. New video documentaries were produced on high quality copra making, preparation of coconut jam, coconut past and vinegar from coconut water.

A 15 minute video documentary on the identification and management of Weligama Coconut Leaf Wilt and Leaf Rot Diseases was produced in collaboration of the Department of Agriculture. This documentary was telecast over Rupavahini. Several copies of this documentary were produced and issued to CCB.

13.3 Radio and TV programmes

The divisional staff participated in three radio programmes, in "Gewaththa" and live programmes in collaboration with the Radio Broadcasting Service of the Department of Agriculture, Narahenpita.

Full details about the on going disease management practices,research and development activities were provided to radio and TV stations to highlight them as news items. One month radio advertisement campaign was completed with the Commercial Service SLBC and Ruhunu Sevaya from 01 to 31 December 2008.

13.4 Print Media

The divisional staff published nine newspaper articles on current issues of the sector.

Half page colour advertisement on the Weligama Coconut Leaf Wilt and Leaf Rot Diseases was published in weekend and daily newspapers in Sinhala.

13.5 Improvement of CRI Museum

CRI museum was developed as an attractive self educational centre for visitors. Items of the museum were rearranged by introducing new posters, exhibits and display boards. Five colourful display boards were installed in the museum.

REPORT OF THE LIBRARY – 2008
Asst. Librarian - P D U C Dharmapala (BLE)

1. GENERAL

The library provided a regular service to the Institutes' staff throughout the year. Services were further extended to university students and other outside clients on request. The number of literature searches made by users both on the coconut databases and bibliographies on coconut. A user seminar was held on 03 November sponsored by CARP at the Computer Unit of the Wayamba University with a view to making the CRI research staff aware of the resources and services available within the AGRINET libraries. It was very successful and 30 scientists participated in the program.

2. ACQUISITIONS

2.1 COLLECTION OF BOOKS AND SERIALS

Due to the budget restrictions of the country , the library failed to purchase books and periodicals during the year. However, 10 books were received from various donors on a complimentary basis. 23 journal titles and Annual Reports were received on an exchange basis and while 05 were complimentary.

2.2 SPECIAL COLLECTION OF COCONUT

The library continuously maintained the coconut databases. A pilot programme was launched by the National Science Foundation to collect full text of CRI publications.

3 SERVICES

3.1 In addition to the quick reference queries made by the staff, 41 literature searches were made on the coconut database to cater to the information needs of staff and university students, both local and foreign.
35 people visited the library during the year for information purposes.

3.2 **External Services**

Resource sharing activities were continued with other AGRINET libraries throughout the year.

Under Inter library loan service 15 articles were requested from AGRINET member libraries of which 90% were received. From 41 requests for articles received from member libraries, 36 were serviced.

3.3 **Contribution to national bibliographies and Database**

Contributions were made towards the compilation of the following integrated databases.
National Agricultural Bibliography
Bibliography on Plant Breeding and Biotechnology

REPORT OF THE ESTATE MANAGEMENT DIVISION

Acting Manager (Estates) – E.P.Gunapala A.P.F.A, BCom (S.P), HNDA

1.GENERAL

The three genetic Resource Centres and seven Sub Stations that come under the Estates Management Division were maintained satisfactorily as a self financial division without depending a treasury fund finance basis. The sub station at middeniya is still developing. This station to serves coconut growers in the southern province conducting various programs to transfer technology . All units were maintained in good order. The recommended cultural practices were carried out during the year.

The total yield of coconut in all nine estates was 4,995,117 out of which 1,416,838 seed nuts were issued for nurseries. Overall income from the estates was approximately Rs. 113 million. The average cost of production (COP) and net sale average (NSA) of all centres were Rs. 14.13 and Rs.20.94 respectively.

2. GENERAL DETAIL OF INDIVIDUAL UNITS.

2.1 Amabekelle Genetic Resource Centre (AGRC) Pallama

Superintendant	-	Mr.D.P.S.K Hettiarachchi
District	-	Puttalm
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	456.20 ha
Total Nut Production	-	1,203,597
Total Seed production out of the total	-	857,509
Total Income from coconut	-	29,767,153
Sundry Income	-	1,601,479
Total Income	-	31,368,632
COP per 1000	-	14,786.63
NSA per 1000	-	24,731.83

2.2 Pallama Genetic Resource Centre (PGRC) Pallama

Superintendant	-	Mr.W.M.U.Rathnayake
District	-	Puttalm
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	252 ha
Total Nut Production	-	419,050
Total Seed production out of the total	-	84,671
Total Income from coconut	-	8,747,036.07
Sundry Income	-	291,299.48
Total Income	-	9,038,335.55
COP per 1000	-	18,293.92
NSA per 1000	-	20,873.49

2.3 Makandura Genetic Resource Centre (MGRC) Makandura,Gonawila

Superintendant	-	Mr.W.A.Herald Upali
District	-	Kurunagala
Agro Climate Zone	-	Intermediate Wet Zone
Extent	-	58.2 ha
Total Nut Production	-	375,838
Total Income from coconut	-	7,886,098
Sundry Income	-	1,416,562
Total Income	-	9,302,660
COP per 1000	-	13,523.03
NSA per 1000	-	20,982.71

2.4 Maduruoya Genetic Resource Centre (MOGRC) Bogaswewa,Kasyapapura

Asst. Superintendant	-	Mr.D.M.I.S.K.Dewameththa
District	-	Polonnaruwa
Agro Climate Zone	-	Dry Zone
Extent	-	85 ha
Total Nut Production	-	594,161
Total Seed production out of the total	-	409,591
Total Income from coconut	-	13,382,718.22
Sundry Income	-	353,617.00
Total Income	-	13,736,335.22
COP per 1000	-	10,755.76
NSA per 1000	-	22,523.72

2.5 Bandirippuwa Research Centre (BRC) Bandirippuwa, Lunuwila

Superintendant	-	Mr.I.A.Nimal Hemasiri
District	-	Puttlam
Agro Climate Zone	-	Intermediate Wet Zone
Extent	-	148.01 ha
Total Nut Production	-	715,483
Total Income from coconut	-	12,127,838.00
Sundry Income	-	2,183,753.00
Total Income	-	14,311,591.00
COP per 1000	-	14,954.37
NSA per 1000	-	16,950.56

2.6 Ratmalagara Research Centre (RRC) Panirendawa

Superintendant	-	Mr.G.B.A.Wijesekara
District	-	Puttlam
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	110.48 ha
Total Nut Production	-	684,181
Total Seed production out of the total	-	11,300
Total Income from coconut	-	11,986,324.48
Sundry Income	-	787,255.25
Total Income	-	12,773,579.73
COP per 1000	-	14,537.88
NSA per 1000	-	17,519.23

2.7 Poththukulama Research Centre (PRC) Pallama

Officer In Charge	-	Mr.D.L,J.Neththasingha
District	-	Puttlam
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	81.73 ha
Total Nut Production	-	886,865
Total Seed production out of the total	-	19,172
Total Income from coconut	-	18,113,979.95
Sundry Income	-	739,337.50
Total Income	-	18,853,317.45
COP per 1000	-	10,510.13
NSA per 1000	-	20,424.73

2.8 Walpita Research Centre (WRC) Walpita

O.I.C	-	Mr.W.A. Herald Upali
District	-	Gampaha
Agro Climate Zone	-	Intermediate Wet Zone
Extent	-	17.08 ha
Total Nut Production	-	90,688
Total Seed production out of the total	-	34,595
Total Income from coconut	-	2,072,589.32
Sundry Income	-	938,466.70
Total Income	-	3,011,056.02
COP per 1000	-	31,207.90
NSA per 1000	-	22,854.06

2.9 Dunkannawa Research Centre (DRC) Thabbowa,Nattandiya

Officer In Charge	-	Mr.N.Gamage
District	-	Puttlam
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	10.04 ha
Total Nut Production	-	25,254
Total Income from coconut	-	523,982.70
Sundry Income	-	1,062,882.44
Total Income	-	1,586,865.14
COP per 1000	-	35,445.70
NSA per 1000	-	20,748.50

2.10 Middeniya Research Centre (MRC) - Middeniya

Asst.Superintendant	-	Mr. Liyanarachchi
District	-	Hambanthota
Agro Climate Zone	-	Intermediate Dry Zone
Extent	-	30 ha

Staff

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Superintendent		1	1		1	1			1		5
Asst-Superintendent	2			1			1			1	5
Field Officer				1							1
Clerk/Typist	1	1				1					3
Office Attenden			1	1	1			1			4
Field Superviser	2	1			3	1	1	1		1	10
T/A	1										1
Field Assitan		1									1
Field Attenden	4	1				1	2				8
Drivers		1			1		1				3
Tracor Drivers			2								2
Watcher	1	1	1		2		4				9
Labour	1										1
Total	12	7	5	3	8	4	9	2	1	2	53

Labour

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Watcher	18	11	4	6	22	8	8	1	1	3	82
cattle Keeper	2	1	2	1	1	3	1		1	1	13
Tractor Drivers	4	3		3	6	2	2			2	22
Polination labour	16	7			3						26
Lab:allowance	2	1	1	1	1	1	1	1	1	1	11
Wakers	25	22	11	20	91	24	14	7	3	8	225
Goat keeper							1				1
Gardener					13		1				14
Gest house Keeper						1					1
Agromy Division						6					6
Electricity/Water						1					1
Total	67	45	18	31	137	46	28	9	6	15	402

Animal Husbandry

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Neat cattle		38	94	35	85	36	32		28	8	356
Buffaloies	56		15		32		13				116
Goat							84				84
Total	56	38	109	35	117	36	129	0	28	8	556

Income Statement

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
From Coconut	28058298	9248941.37	9362945	10076836.71	10969620.21	12182069.59	15118306.77	1254228	548518.96		96819764.61
Sundry income	2262497	1060693.65	1054157	460206.00	1557927.79	28736.50	293387.50	580762	854379.00	414663	8567409.44
Total	30320795	10309635.02	10417102	10537042.7	12527548.00	12210806.09	15411694.27	1834990	1402897.96	414663	105387174.05

Income,Expenditure,COPand NSA Statement

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Income Coconut	29767153	8747036.07	7886098	13382718.2	12127838	11986324.5	18113979.95	2072589	523982.7		104607719.74
Expenditure	17797139	7666066.7	5082470	6390651.29	10699601	9946539.67	9321062.34	2830182	895145.74		70628857.75
COP per 1000	14786.63	18293.92	13523.03	10755.76	14954.37	14537.88	10510.13	31207.9	35445.7		14139.58
NSA per 1000	24731.83	20873.49	20982.71	22523.72	16950.56	17519.23	20424.73	22854.06	20748.5		20942.00
Profit(loss)1000	9945.2	2579.57	7459.67	11767.97	1996.19	2981.35	9914.61	8353.84	14697.2	0	6802.42

Profit/Loss Statement

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Income Coconut	30320795	10309635.02	10417102	10537042.71	12527548	12210806.09	15411694.27	1834990	1402897.96	414663	105387174.05
Expenditure	23004525	6948836.61	7735734	8522664.03	13167006	10154757.00	10494281.52	3443757	1711358.52		85182919.68
Net Profit(loss)	7316270	3360798.41	2681368	2014378.68	-639458.00	2056049.09	4917412.75	1608767	-308460.56	414663	20204254.37

Cultural prectices done

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Item											
Fertilyzing	11100	8182	3057	6292	11432	1897	1600	500		2819	46879
Weeding	350	432.00	130	189	205	200.00	194	30	25	42	1797
Mulching	15000	16600	5310	12390	11432	5000	5800	500	317	1000	73349
Fencing repair	300	568	515	3027		750	568	22		250	6000
Tying hara	10999	2823					1022				14844
Draning				2290							2290
Huskpits											0
Motor roads		1							0.5		2
Infilling	560	1067		266						67	1960
Levelling ant hill Nos				50							50
Removel of palms		355									355
Censes		174.82		85			78.51	44	10.08	8.5	401
Pest & disease	2000	23800		10765		1783			1000	4	39352
Cover Crop		2.5									3
Land peparetion	12	11									23
Planting holes Nos		1000									1000

Extent-Acres

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Mature area	318.6	190.0	140.4	88.0	205.0	196.6	194.0	30.3	5.2		1368.1
Immature area	9.8	242.0		59.4	2.5	43.7		8.0	15.5	45	425.9
Bear land	7.6	84.0		50.6		2.8		1.2	1.3	10	157.5
Road & Building	9.8	10.0	2.6	3.0	157.0	8.0	8.0	4.5	1.0		203.9
Jangal	780.5	97.0	1.0	10.0		14.5			2.0	7	912.0
Other crops						4.9				13	17.9
Nursery					3.7	2.5					6.2
											0
Total	1126.3	623.0	144.0	211.0	368.2	273.0	202.0	44.0	25.0	75	3091.48

Palms Cences

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Bearing Palms	17749	8948	5693	7725	11285	11330	9987	1404	321		74442
Young Palms	615	6900	0	496	147	1596	87	0	840	0	10681
Seedling	1000	3378		141	1883	358	73	487	122	2819	10261
Dud Palms	94	3041	187	147	805	382	489	28			5173
Ded Palms	30	41			0		0				71
Vacancies	7721	2219	4346	5869	4808	2552	2865	647	0	0	31027
											0
											0
Total	27209	24527	10226	14378	18928	16218	13501	2566	1283	2819	131655

Crop Statement

	Ambakelle	Pallama	Makadura	Maduru-Oya	Bandiripp	Ratmala	Pottukkula	Walpita	Dunkanna	Middeniya	Total
Discription	CGRC	CGRC	CGRC	CGRC	RC	RC	RC	RC	RC	RC	
Total Crop	1203597	419050	375838	594161	715483	684181	886865	90688	25254		4995117
Crop Disposal											
Fresh Nut - Sold	254703	301906	353033	141987	527538	637198	821466	52176	23327		3113334
Seed Nuts-Sold	857509	84671		409591		11300	19172	34595			1416838
Nut Allowances	5946	4282	5919	7387	55683	6581	3826	1320	712		91656
Nursery	29045	4506		7000							40551
Cured	4474	6806	4069	10249	98901	7014	13447	1042	272		146274
Rejection-Burnt	51920	16879	12817	17947	33361	22088	28954	1555	943		186464
Balance	0	0	0			0	0	0	0		0
Total	1203597	419050	375838	594161	715483	684181	886865	90688	25254		4995117

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 2008, is given in table 1.

Table 1 : ***Staff position as at 31/12/2008***

Grade	Ungraded	Sp C1	C1 I	C1 II	C1 III	C1 IV	Total
Executive	02	00	10	15	13	33	73
Technical	00	36	08	05	-	-	49
Intermediate	00	04	00	00	-	-	04
Clerical & Allied	00	22	03	02	-	-	27
Operative	00	25	04	07	-	-	36
Driver	00	19	04	03	-	-	26
Minor	00	41	12	10	-	-	63
Watcher	10	00	00	00	-	-	10
Grand Total	12	147	41	42	13	33	288

3. WELFARE

Welfare facilities extended towards the employees from the Board were continued. Financial assistance extended to the employees are given below:

3.1 Financial Aid

Provident Fund Loans: Granted for 65 employees, amounting to Rs.24,288,200.00

Distress Loans: Granted for 23 employees amounting to Rs. 3,978,373.00

Transport Loans: Granted for 11 employees amounting to Rs. 533,500.00

Refrigerator Loans : Granted for 02 employee amounting to Rs. 24,000.00

Medical Aid: Rs.3,880,720.00 was reimbursed by the Medical Aid Scheme during the year 2008, and an amount of Rs.1,294286.00 was distributed to 320 Savings Accounts of Members.

The following medical clinics were conducted during the year 2008

- Blood Donation Programme
- Medical Check up for members & their immediate family through Asiri Hospitals (Pvt) Ltd.
- Check the Blood Sugar of members of Medical Aid Scheme

3.2 Other facilities to employees

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 2008.

STAFF MATTERS

4. APPOINTMENTS

04 appointments were given during the year 2008, and the details are given in Table 2:

Table 2: ***Appointments made during the year 2008***

Name	Designation	Division/Unit	Date
Mr. T M A P Kumarasinghe	Vehicle Attendant	Establishment Unit	08.07.08
Mr. S H A M Premaratne	Vehicle Attendant	Establishment Unit	08.07.08
Mr. M A A Chandrathilaka	Watcher	Estates Management	08.07.08
Mr. I H D Senarath	Binder	Technology Transfer Division	08.07.08

5. RESIGNATIONS, RETIREMENTS, VACATION OF POSTS & TERMINATIONS OF SERVICES & DEATHS

The details are given in Table 3:

Table 3 :

Name	Designation	Division/Unit	Date
Resignations:			
Mrs. D C L Hapuarachchi	Senior Technical Officer	Crop Protection Division	01.01.08
Mrs. M M S P Fernando	Stenographer (English)	Establishment Unit	05.02.08
Mr. I R Wickramananda	Senior Research Officer	Crop Protection Division	12.05.08
Mrs. W M Gnanawathi	Senior Lab/Field Attendant	Soils & Plant Nutrition Division	01.06.08
Mr. H W A N Nandakumara	Asst. Estates Superintendent	Estates Management Division	31.07.08
Mr. K D P P Gunathilaka	Research Officer	Coconut Processing Research Division	09.10.08
Mr. H W A S Senaratne	Assistant Livestock Officer	Estates Management Division	01.12.08
Retirements:			
Mr. S M Somaratne	Senior Lab/Field Attendant	Soils & Plant Nutrition Division	13.02.08
Mr. B M D Bandara	Chief Clerk	Establishment Unit	28.02.08
Mr. Y H Wijesena	Senior Clerk/Typist	Establishment Unit	25.04.08
Mr. R A Chandrasekara	Senior Office Attendant	Establishment Unit	08.05.08
Mr. W P Fernando	Lab/Field Assistant	Agronomy Division	28.05.08
Mr. S A V Appuhamy	Senior Driver	Establishment Unit	29.06.08
Mrs. C M B I Salwathura	Senior Clerk/Typist	Accounts Unit	04.07.08
Mr. N M H Wijewardena	Senior Clerk/Typist	Establishment Unit	03.08.08
Mr. M D V Saparamadu	Senior Lab/Field Assistant	Agronomy Division	12.08.08
Mr. R M Dharmasena	Senior Guest House Keeper	Estates Management Division	13.08.08
Mr. W E R C Fernando	Senior Lab/Field Assistant	Biometry Division	03.09.08
Mr. W F T Fernando	Senior Supplies Assistant	Establishment Unit	25.11.08
Mr. D J M Leelaratne	Clerk/Typist	Accounts Unit	28.11.08

Deaths

Mr. K D L Gunathilaka	Watcher	Estates Management Division	13.05.08

Vacation of Post

Mr. J M P K Jayasekara	Foreman(Building)	Engineering Unit	23.04.08
Dr. J M M N Marikkar	Senior Research Officer	Coconut Processing Research Division	03.07.08

6. PROMOTIONS

6.1 PROMOTIONS IN NON-EXECUTIVE GRADES

No promotions in non-executive grades were given during the year 2008.

6.2 PROMOTIONS IN EXECUTIVE GRADES

Following Promotions in Executive Grades were implemented during the year 2008, as shown in Table 4

Table 4: ***Promotions in Executive Grades during the year 2008***

Executive Grade Class III to Class II

Name	Designation	Division	Effective Date
Mrs. M A D W S Madurapperuma	Senior Research Officer	Plant Physiology Division	16.05.2007
Dr. (Mrs.) P I P Perera	Senior Research Officer	Tissue Culture Division	01.02.2008
Dr.(Mrs.) D M D I Wijebandara	Senior Research Officer	Soils & Plant Nutrition Division	31.03.2008

7. TRANSFERS

1. Mr. W.M.N.G. Wijayatunga Supervisor from Ambakelle Genetic Resource Center to Bandirippuwa Research Center – On February 01

2. Mr. M.P.W. Fernando Senior Supervisor from Bandirippuwa Research Center to Ambakelle Genetic Resource Center – On February 01

3. Mr. M.A.S. Marasinghe Senior Lab & Field Attendant from Pallama Genetic Resource Center to Poththukulama Research Center – On`` February 01

4. Mr. A.P.C. Pradeep Supervisor from Poththukulama Research Center to Makandura Genetic Resource Center – On February 05

5. Mr. W.M.U. Ratnayake from Ambakelle Genetic Resource Center to Pallama Genetic Resource Center – On February 01

6. Mr. D.P.S.K. Hettiarachchi from Estates Management Division to Ambakelle Genetic Resource Center – On February 01

7. Mr. S.A.S. Chandrasiri from Ambakelle Genetic Resource Center to Genetics & Plant Breeding Division – On February 18

8. Mr. A.A. Fernando from Genetics & Plant Breeding Division to Ambakelle Genetic Resource Center – On February 11

9. Mr. R.P. Newil from Internal Audit Unit to Estates Management Division – On January 01

10. Mr. J.K.J. Perera from Deputy Director (Adm. & Fin.) Office to Internal Audit Unit – On January 01

11. Mrs. I.B. Daywathi from Director's Office to Deputy Director (Adm. & Fin.) Office – On January 01

12. Mr. H.A.D. Rexie from Deputy Director (Research) Office to Director's Office – On January 01

13. Mr. H.K.A.N. Appuhamy Tractor Driver from Bandirippuwa Research Center to Makandura Genetic Research Center – On February 01

14. Mrs. H.M.W.S. Athauda Senior Stenographer (English) from Deputy Director (Research) Office to Deputy Director (Adm. & Fin) Office – On February 01

15. Mrs. M.P. Premaratne Senior Stenographer (English) from Deputy Director (Adm. & Fin.) Office to Director's Office – On February 01

16. Mrs. H.M.A. Herath Senior Stenographer (English) from Soils & Plant Nutrition Division to Deputy Director (Research) Office – On February 01

17. Mr. H.D.J. Canisius Senior Office Attendant from Engineering Unit to Agricultural Economics & Agribusiness Management Division – On February 01

18. Mrs. K.V.N.N. Jayalath Research Officer from Agronomy Division to Agricultural Economics & Agribusiness Management Division – On February 11

19. Mr. T.M.C. Peiris Senior Tractor Driver from Bandirippuwa Research Center to Transport Unit – On February 26

20. Mr. D.M.L. Jayaratne Watcher from Poththukulama Research Centre to Ambakelle Genetic Resource Center – On August 01

8. LOCAL TRAININGS (More than 5 days)

1. Mrs. K P Waidyaratne/Research Officer followed a course on Statistical Packages for Data Analysis at Applied Statistics Association of Sri Lanka from 25 January (Five weeks every Friday)
2. Mr. M R U Attanayka/Senior Audit Clerk followed a training programme in Basic Business Accounting at Institute of Government Accounts & Finance from 2 – 6 June

3. Mr. J D J S Kularatne/Senior Technical Officer followed a Certificate course in Computer Networking & Administration at National Institute of Business Management from 25 April (03 months , Every Sunday)

4. Mrs. C P A Kurundukumbura/Senior Technical Officer followed a Certificate Course in Laboratory Management at National Institute of Business Management from 27 May (16 Tuesdays)

5. Mr J D J S Kularathna was awarded the MPhil Degree, from the PGIA, University of Peradeniya on 31 October 2008.

6. Mr. M G M K Meegahakumbura/Research Officer, Mrs. L L W C Yalegama/Senior Research Officer, Miss. A K F Nadheesha/Research Officer, Mrs. K V N N Jayalath/Research Officer, Mrs. P M E K Pathiraja/Research Officer followed a course on Statistical Packages for Data Analysis at Applied Statistics Association of Sri Lanka from 25 July to 22 August (05 Fridays).

7. Mrs. H M I K Herath/Research Officer followed a short course on GIS and it's Applications at Postgraduate Institute of Science from 13 – 18 October

8. Mrs. H M I K Herath/Research Officer, Mrs. K P Waidyaratne/Research Officer, Mr. L R M C Liyanage/Assistant Research Officer, Mr. K P A Pathirana/Technical Officer participated for 29th Asian conference on remote sensing at Survey Department of Sri Lanka from 10 – 14 Novermber

9. Mrs. K P S Jayathilaka/Senior Clerk/Typist followed a Diploma in Human Resource Management at National Institute of Business Management from 26 November (One year)

10. Mrs. W S R Fernando/Senior Clerk/Typist followed a Diploma in Business Management at National Institute of Business Management from 26 November (One year)

11. Dr. R.P.B.S.H.S. Senarathne successfully completed his postgraduate studies leading to Ph.D. degree at the Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka on 25th January 2008.

12. Miss.S.C.Smasiri, Research Officer is continuing her postgraduate studies leading to an MPhil degree at the Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

13. Dr. L Perera, Dr. (Miss) S A C N Perera, Miss H D M A C Dissanayake and Mr. M G M K Meegahakumbura participated in the User Seminar of AGRINET for researchers at CRI organized by CARP. 3rd November 2008, Wayamba University of Sri Lanka, Makandura

14. Miss. M.K. Fathima Nadheesha, Mrs. H.M.I.K. Herath and Mr. L.R.M.C. Liyanage participated a workshop on 'User Seminar Agrinet' held on 03rd November 2008 at Wayamba University of Sri Lanka, Makandura, Gonawila.

15. Mr. L.R.M.C. Liyanage participated a workshop on Positive Thinking and Productivity Development on 02nd, 09th June and 16th July 2008 held at Coconut Research Institute, Lunuwila.

16. Dr. N.A. Tennakoon, Dr. D.M.D.I. Wijebandara, Miss. M.K. Fathima Nadheesha, Mrs. H.M.I.K. Herath, Mr. L.R.M.C. Liyanage, Mr. D.P. Panditharatne, Mr. U.S.S. Perera and Mr. K.L. Ranasinghe participated a Symposium on Plantation Crop Research on 16th and 17th October 2008 held at BMICH conducted by Tea, Rubber, Coconut and Sugarcane Research Institutes of Sri Lanka.

17. Dr. D.M.D.I. Wijebandara, Miss. M.K. Fathima Nadheesha, Mrs. H.M.I.K. Herath, Mrs. H.L.A.P. Liyanage and Mr. W. Gunasena participated a workshop on Preparation and Usage of Compost on 24th June 2008 at Agriculture Research Center at Makandura.

18. Mrs K P Waidyarathna participated in the workshop on "GIS and its Applications (Residential program)" conducted at the Post Graduate Institute of Science from 20 - 26 April, 2008.

9. OVERSEAS VISITS

1. Dr D B T Wijeratne/Chairman Coconut Research Board visited accompanying the Hon. Minister of Agriculture on an official assignment in California, U S A from 06 – 20 February.

2. Mr. J M D T Everard/Deputy Director (Research) participated at the International Conference on "Recent Advances in Biotechnology" in Islamabad , Pakistan from 17 – 20 March.

3. Dr.(Mrs.) C Jayasekara/ Director, Coconut Research Institute participated at the 43rd COCOTECH Meeting in Manado , Indonesia from 04 – 09 August.

4. Dr. A A F L K Perera/Head, Genetics & Plant Breeding Division participated in the Annual Research Meeting in Thailand from 15 - 21 September.

10. OVERSEAS TRAININGS

1. Dr.(Mrs.) P I P Perera/Senior Research Officer participated at the Training & Research workshop on Coconut Embryo Culture in Philippine from 09 – 12 December.

2. Mr. M G M K Meegahakumbura participated in the Training and Research Workshop for coconut embryo culture to improve collecting and safe movement of germplasm, organized by the Coconut Genetic Resources Network (COGENT) and Global Crop Diversity Trust. 11-15th December 2008, Zambounga Research Station, The Philippines.

3. Miss. J M M A Jayasundara/ Research Officer attended Postgraduate training Ph.D (Food Technology) in University of Queensland Australia from 02 January 2008 to 01 January 2012.

4. Mr. I .M. S. K. Idirisinghe (Senior Research Officer) continued his studies in Thomas Bata University, Czech Republic.

5. Mr. C.S. Herath (Extention Officer) continued his studies in Thomas Bata University, Czech Republic.

6. Mrs. D.M.D.I. Wijebandara, Research Officer has completed her PhD thesis on 31.03.2008. The title of the thesis was "Studies on distribution and transformation of soil Zn and response of rice to nutrients in traditional and System of Rice Intensification (SRI) methods of cultivation".

11. 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 2008.

Buses	-	03
Lorries	-	03
Vans	-	07
Cars	-	03
Cabs	-	13
Jeeps	-	06
Motor bicycles	-	68
Three Wheelers	-	03
		106

12. DEBTORS DUE TO VIOLATION 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. Mrs. P.G.P.Hewawitharanage	Rs. 2,993,945.18
6. Dr.(Mrs) C.K.Banadaranayake	Rs. 3,371,612.63
7. Mr. N.A.K. De Silva	Rs. 3,204,297.60

13. FINANCE UNIT

Total budgetary allocation for this year was Rs. 314.908 million and out of which Rs. 178.241 million under recurrent expenditure and Rs. 136.667 million under capital expenditure. The government grant received was Rs. 180.7 million.

Preparation of Institutional Budget, monthly cash flow and the final accounts were the main functions of the Unit in addition to preparing monthly salaries and making routine payments.

14. ENGINEERING UNIT

Engineering Unit carried out maintenance work of buildings, vehicles, machineries, electricity and water supply, telecommunication, refrigeration and air-conditioning systems at Bandirippuwa Research Station. Also attended in supervision of the maintenance activities of the above mentioned fields in the estates. During the year 2008 Engineering Unit completed the following repair and maintenance works at Bandirippuwa Research Station.

- Repairing of Ceiling of Plant Physiology Division.
- Water tank structures (10 Nos.) to the staff quarters
- Repairing of old Genetics & Plant Breeding Building.

STAFF PUBLICATIONS/ ACADEMIC AND PROFFESSIONAL ACTIVITIES/ COMMUNICATIONS AT SCIENTIFIC MEETINS/ PARTICIATION OF CRI STAFF IN OTHER STATUTORY BODIES AND COMMITIEES

STAFF PUBLICATIONS

Aratchige N S, Fernando L C P, Kumara A D N T, Suwandharathne N I, Perera K F G, Hapuarachchi D C L, and De Silva P H P R (2008). Recent advances in research on biological control of the coconut mite *Aceria guerreronis* Keifer in Sri Lanka. *In:* Proceedings of the Second Symposium on Plantation Crop Research – Export Competitiveness Throughthrough Quality Improvements (Eds. Nainanayake N P A D, and Everard J M D T). Coconut Research Institute, Lunuwila, Sri Lanka held in BMICH, Colombo on 16-17 October. PP 313-321.

Aratchige N S, Sabelis M W, and Lesna I (2008). Effect of coconut mite-induced changes in coconuts on the searching behaviour of predatory mites. *Neoseiulus baraki. In:* Proceedings of the Second Symposium on Plantation Crop Research – Export Competitiveness Throughthrough Quality Improvements (Eds. Nainanayake N P A D, and Everard J M D T). Coconut Research Institute, Lunuwila, Sri Lanka held in BMICH, Colombo on 16-17 October. PP 187-198.

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Dissanayaka H D M A C, Perera S A C N, Fernando W B S, Attanayake R B, Meegahakumbura M G M K, and Perera L (2008). Evaluation of the comparative performance of five commercial coconut cultivars under two different agro-ecological zones in Sri Lanka. *In:* Proceedings of the Second Symposium on Plantation Crop Research – Export Competitiveness Through Quality Improvements (Eds. Nainanayake N P A D, and Everard J M D T). Coconut Research Institute, Lunuwila, Sri Lanka held in BMICH, Colombo on 16-17 October. Samayawardena Printers, Colombo.

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PARTICIPATION IN OTHER STATUTORY BOARDS AND COMMITTEES

Dr. (Miss) S A C N Perera served as a committee member for the National Committee of CARP on Plant Breeding and Biotechnology

Dr. L Perera and Mr. R Jayathilake served as committee members for the National Nursery Technology Advisory committee, CCB & CRI.

Dr. L Perera, Dr. (Miss) S A C N Perera and Mr. M G M K Meegahakumbura served as the committee members of the technical advisory committee on estate management (CRI)

Dr. L Perera served as a member in the annual transfers committee of CRI

Dr.N.A. Tennakoon

Member of the working group for Standardization of Organic Fertilizer of Sri Lanka Standard Institution.

Member of the Advisory Committee on Fertilizer of the Honorable Minister of Agriculture

Member of the National Committee on Organic Fertilizer, Ministry of Agriculture, Battaramulla.

Member of the National Organic Certification Body and Development of Organic Production Base in Sri Lanka for domestic Consumption and Export, Govijana Mandiraya, Battaramulla.

Chairman of six (06) Technical Evaluation Committees in Coconut Research Institute and Coconut Cultivation Board.

Mr. L.R.M.C. Liyanage

Member of the Technical Evaluation Committee of PVC and Accessories for Coconut Research Institute.

Member of National Level Fertilizer Sampling and Quality Assessment Programme of National Fertilizer Secretariat, Colombo.

Mrs K P Waidyarathna
Representative of CRI in the Applied Statistics Association of Sri Lanka.

Mr J D J S Kularatna
INFORM coordinator for the Council of Agricultural Policy (CARP),

K V N N Jayalath
Member of the panel of judges in 8th Agricultural Research Symposium, 2008, held on 13-14 August, Faculty of Agriculture and Plantation Management, Wayambe University of Sri Lanka, Makandura, Gonawila,

MEETINGS, WORKSHOPS AND SEMINAR PARTICIPATION

Dr. (Miss) S A C N Perera participated in the capacity of a committee member of CARP in a workshop on 'Public awareness on/and Public participation in Agricultural Biotechnology', organized by CARP and FAO held on 6-7th May 2008 at Gannoruwa. Participated as a member of the committee of Plant Breeding and Biotechnology in the workshop,

Dr. (Miss) S A C N Perera participated in a workshop in the capacity of a committee member of CARP on plant breeder's rights and legal aspects organized by CARP and FAO held at the University of Colombo on 13th October 2003.

Dr. (Miss) S A C N Perera represented CRI in a workshop on formulating an investment plan for Sri Lanka on Biotechnological research organized by CARP and FAO on 16th December 2008.

Dr. L Perera and Mr. R Jayathilake participated in the one day workshop on Seed act amendment and Dr. L Perera delivered a lecture on " Quality assurance measures adopted by CRI in coconut planting material production", In-service Training Institute, Gannoruwa, Peradeniya, 30 September 2008.

Mrs K P Waidyarathna made a presentation on change in onset of monsoon rains on invitation at the annual sessions of Applied Statistics Association of Sri Lanka, held on 7th January 2008.

Mr. J.R.K Asanka and Mrs. J.A.K.M., Fernando participated in series of coir steering committee meetings organized by Entergrowth, Industrial Development Board and International labour Organization.

Mrs. J.A.K.M., Fernando participated in coir steering committee meeting organized by Industrial Technology Institute under the Project "Pilot facility for efficient coir processing and quality control" funded by Common Fund of Commodities (CFC).

Mrs.P.D.U.C. Dharmapala attended several AGRINET and SLSTINET Meetings.

ACADEMIC AND PROFESSIONAL ACTIVITIES

Dr. L Perera, Dr. (Miss) S A C N Perera, Miss H D M A C Dissanayake and Mr. M G M K Meegahakumbura and the technical staff of the Genetics & Plant Breeding Division conducted the National Workshop on "Application of biotechnologies in Plants and Pathogens". jointly organized by CARP and CRI and sponsored by FAO. CRI, Lunuwila. 1-5 December 2008.

Dr. L Perera and Dr. (Miss) S A C N Perera served as the course coordinators for the National Workshop on "Application of biotechnologies in Plants and Pathogens". jointly organized by CARP and CRI and sponsored by FAO. CRI, Lunuwila. 1-5 December 2008.

Dr. L Perera Served as a resource person for the Resource workshop on "Phytoplasma disease in plants with special reference to coconut and delivered a lecture on "Molecular diagnosis of Weligama Coconut Leaf Wilt Disease". 15-17 May 2008. Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo, Sri Lanka.

Dr L Perera served as a reviewer for the Annual Congress of the Postgraduate of Institute of Agriculture, University of Peradeniya, 2008.

Dr (Miss) S A C N Perera served as a reviewer for the Agricultural Symposium of the Department of Agriculture (ASDA) 2008.

Dr. (Miss) S A C N Perera supervised the final year research project of Miss. L C J Kamaral of the Department of Biotechnology, Faculty of Agriculture and Plantation Management of the University of Wayamba.

Dr. (Miss) S A C N Perera supervised the final year research project of Miss. R D Kannangara of the Department of Botany, University of Sri Jayawardanapura.

Dr. (Miss) S A C N Perera served as the research supervisor for Ms. Priyanka Molligoda MSc student at the Post Graduate Institute of Science, Peradeniya.

Dr. (Miss) S A C N Perera served as the research supervisor for Mr. G K Ekanayake, M.Phil student of the University of Sri Jayawardanapura.

Dr. L Perera served as a judge at the Biotechnology and Plant Breeding session in the Annual Congress of the Postgraduate of Institute of Agriculture, University of Peradeniya, 2008.

Dr. L Perera and Mr. M G M K Meegahakumbura served as judges at the Biotechnology session in the 8th Agricultural Research Symposium of the Faculty of Agriculture and Plantation Management, Wayamba University, Makandura, 13 August 2008.

Dr. (Miss) S A C N Perera made a presentation on "Progeny Evaluation trials: Revelations over two decades'' under the CRI in-house seminar series, CRI Auditorium.

Mr. G K Ekanayake made a presentation on 'Assessment of the Genetic Diversity of Coconut with special reference to phenotypes in the Southern Province of Sri Lanka on 31st October 2008 at Research Forum, University of Sri Jayawardanapura.

Dr. N.A. Tennakoon and Miss. M.K. Fathima Nadheesha supervised B.Sc (Agric) final year research project of Miss. H.G.W. Pushpakumari in University of Wayamba. The title of the

project was "Effect of some commercial Bio Fertilizer on the growth of coconut seedlings and availability of soil nutrients".

Dr. N.A. Tennakoon and Miss. M.K. Fathima Nadheesha supervised a B.Sc. final year research project of Miss. K.D.G. Fernando in University of Kelaniya. The title of the project was "Cadmium accumulation in soil, leaf, kernel and nut water of coconut after long-term application of different phosphate sources".

K V N N Jayalath supervised two final year undergraduate student projects of the University of Wayamba and one undergraduate student project University of Rajarata which is a partial requirement for the fulfillment of B.Sc. Agriculture degree requirement.

P. M. E. K. Pathiraja supervised two final year undergraduate student projects which is a partial requirement for the fulfillment of B.Sc. Agriculture degree of the University of Wayamba.

REPORT OF THE ACCOUNTS 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			
	2005	2006	2007	2008
Treasury Grant – Recurrent	77.00	99.80	122.10	122.70
Treasury Grant – Capital	24.60	17.40	26.97	58.00
Income Self-finance Units	58.62	68.77	106.41	118.09
CRI Own Income	5.76	6.57	10.51	09.23
CESS Grant	57.48	55.00	56.50	-
Donor Funded Projects	7.29	8.18	0.93	2.33
Total	230.75	255.72	323.42	310.35

As shown in Table 1, the capital grant has increased by 53.1 % in the year 2008 compared to year 2007. The income generated by self-financing unit operations for the year increased by 9.9% to reach Rs, 118.09 Millions. The CESS allocation has been suspended by Treasury in the year 2008.

Table 2 : ***Financial progress of recurrent expenditure***

Description	Rs. Million		(Decrease) %
	2007	2008	Increase
Personnel Emoluments	92.90	88.31	(05%)
Travelling Expenses	1.86	0.88	(52%)
Supplies and Requisites	15.75	12.95	(17.7%)
Maintenance Expenses	15.22	13.32	(12.5%)
Contractual Expenses	6.22	6.64	6.7%
Other Recurrent Expenses	3.75	3.73	(0.5%)
Total Recurrent Expenses	**135.70**	**125.83**	**(7.3%)**

The staff position of the CRI was 687 employees during the year 2008. Out of them 284 were permanent employees and 403 were daily paid workers in research substations and genetic

resources centres . As indicated in Table 2, 70% of the total recurrent expenditure was on personnel emoluments of permanent employees except resource centre staff 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 capital expenditure***

Description	**Rs. Million**	
	2007	**2008**
Vehicle	4.49	
Office Furniture & Equipment	1.15	0.81
Machinery & laboratory Equt.	6.44	4.60
Building & Structure	-	9.23
R/D. Expenses	15.34	36.33
Other Capital Expenditure	2.30	2.30
Total Capital Expenses	**29.72**	**53.27**

Table 4: ***Financial Progress of Self-financing Units***

Seed Gardens/ Research Centers	**Year 2008**		**Surplus/ (Deficit)**
	Income Rs. Million	**Expenditure Rs. Million**	
Ambekela Genetic Resources Center	31.94	17.43	14.51
Pallama Genetic Resources Center	10.39	7.60	2.80
Makandura Genetic Resources Center	8.16	6.05	2.10
Maduruoya Genetic Resources Center	15.46	6.23	9.22
Bandirippwa Research Staton	14.15	11.66	2.50
Rathmalagara Research Center	14.95	10.48	4.48
Walpita Research Center	3.03	2.85	0.18
Pottukulama Research Center	17.96	8.31	9.65
Dunkannawa Research Center	1.70	1.95	(0.26)
Estates Management Division	0.35	5.22	(4.87)
Total	**118.09**	**77.78**	**40.31**

Dunkannawa Research Center had been vested recently and therefore this estate are in an improvement stage.

COCONUT RESEARCH INSTITUTE

ESTABLISED UNDER COCONUT DEVELOPMENT ACT NO. 46 OF 1971

BALANCE SHEET AS AT 31 DECEMBER 2008

		YEAR 2008 Rs.	YEAR 2008 Rs.	YEAR 2007 Rs.
ASSETS				
PROPERTY,PLANT & EQUIPMENT	NOTE-01	1,830,713,605.66		1,812,909,589.67
RESEARCH & DEVELOPMENT	NOTE-01.1	54,224,780.02		42,703,354.50
LIBRARY BOOKS		6,988,345.18		6,988,345.18
			1,891,926,730.86	1,862,601,289.35
CURRENT ASSETS				
STOCKS	NOTE-02	60,724,750.66		49,302,159.92
DEBTORS LESS PROVISION	NOTE-03	9,660,564.16		5,414,698.69
PURCHASE ADVANCES	NOTE-04	6,919,097.63		12,282,727.45
LOANS AND ADVANCES TO EMPLOY	NOTE-05	15,402,161.15		15,598,621.72
DEPOSITS RECEIVABLE		1,728,927.00		1,703,927.00
SAVING DIPOSIT	NOTE-06	22,623,928.00		6,000.00
PREPAYMENTS		366,720.84		366,720.84
I.A.E.A. PROJECT		5,513.29		5,513.29
CASH -IN -TRANSIT		4,051,062.98		73,253.20
CASH & CASH EQUIVALANTS	NOTE-07	49,094,867.44		51,061,451.62
			170,577,593.15	135,815,073.73
TOTAL ASSETS			2,062,504,324.01	1,998,416,363.08
LESS :- LIABILITIES				
CURRENT LIABILITIES				
SUNDRY CREDITORS	NOTE-08	285,547.17		718,477.76
ACCRUED EXPENSES		21,585,628.12		20,618,837.85
EXPENCE CREDITORS		11,138,839.03		3,465,144.94
DEPOSITS PAYABLE	NOTE-09	4,320,915.99		2,654,264.39
ON GOING PROJECTS	NOTE-10	616,723.47		616,723.47
WORKING CAPITAL			37947653.78	28,073,448.41
NON CURRENT LIABILITIES				
PROVISION FOR GRATUTY			81,279,512.61	75,848,148.35
			119,227,166.39	103,921,596.76
TOTAL NET ASSETS			1,943,277,157.62	1,894,494,766.32
NET ASSETS/EQUITY				
AUTHORISED CAPITAL				18,000,000.00
CONTRIBUTED CAPITAL CF & CESS	NOTE-11	492,603,326.77		434,603,326.77
COTRIBUTED CAPITAL-PROJECT		5,615,164.85		5,449,869.85
FOREIGN AID		634,078.78		634,078.78
LOCAL AID		5,982,748.19		6,242,969.57
REVALUATON RESERVE		1,709,930,959.14		1,709,930,959.14
REVENUE RESERVE	NOTE-12	-271,489,120.11		-262,366,437.79
			1,943,277,157.62	1,894,494,766.32

COCONUT RESEARCH INSTITUTE

STATEMENT OF FINANCIAL PERFORMANCE FOR THE YEAR ENDED 31st December 2008

ILLUSTRATION THE CLASSIFICATION OF EXPENSES BY NATURE

	YEAR2008 Rs.	YEAR2007 Rs.
OPERATING REVENUE		
RECURRENT GRANT	127,700,000.00	127,100,000.00
ESTATE INCOME	118,091,884.51	106,407,114.84
INTEREST ON LOAN & INVESTMENT	590,003.09	598,114.23
INCOME FROM MORTOR VEHICLES	2,083,021.94	3,868,233.96
SUNDRY INCOME	6,320,352.59	5,753,589.68
SALES OF PHEROMONE	141,050.00	180,600.00
SALES OF MONOCROTOPHOSE	90,660.00	115,220.00
INCOME PROJECTS	2,330,172.76	928,376.60
INCOME CESS	-44,057.71	1,242,007.90
	257,303,087.18	246,193,257.21
OPERATING EXPENSES		
SALARIES ALLOWANCES & OVER TIME	71,311,617.45	70,999,445.43
BOARDS CONTRIBUTION TO ETF/EPF	11,835,065.15	15,444,037.46
BOARDS CONTRIBUTION TO MEDICAL AID	4,727,173.44	6,075,990.49
COCONUT ALLOWANCES	322,869.51	273,951.90
ESTATE GENERAL CHARGES/UPKEEP	81,035,416.34	81,296,762.78
TRAVELLING	883,911.73	1,857,596.70
SUPPLIERS & CONSUMABLE	12,951,927.00	15,748,069.65
MAINTAINNANCE	13,321,553.50	15,220,576.08
CONTRACTUAL SERVICES	6,644,822.52	6,222,936.32
DEPRECIATION & AMORTISATION EXPENSES	39,005,447.43	30,802,164.04
EXPENSES - PROJECTS	2,135,858.22	2,930,500.38
EXPENSES - CESS	7,567,545.06	9,646,451.42
BOARD MEMBERS FEES	113,000.00	111,320.00
GRATUITY	11,526,107.74	9,353,316.79
OTHER OPERATING EXPENSES	3,727,055.12	3,745,097.23
TOTAL OPERATING EXPENSES:		
	267,109,370.21	269,728,216.67
SURPLUS/(DEFICET) FROM OPERATING ACTIVITIES	-9,806,283.03	-23,534,959.46
GAIN ON SALES OF PROPERTY PLANT & EQUIPMENT	-938,008.84	
TOTAL NON OPERATING REVENUE (EXPENSES)	-10,744,291.87	-23,534,959.46

COCONUT RESEARCH INSTITUTE

PROGRAMME - 13 - WORKING ACCOUNT ESTATE

ITEM	BANDIRIPP--UWA ESTATE Rs.	RATHMALA--GARA ESTATE Rs.	AMBAKELLE SEED GARDEN Rs.	POTTHUKU-LAMA RESEARCH STATION Rs.	WALPITA ESTATE Rs.	MAKANDURA SEED GARDEN Rs.	MADURUOYA SEED GARDEN Rs.	PALLAMA SEED GARDEN Rs.	DUNKANNAWA ESTATE Rs.	ESTATE ANAGEMANT DIV Rs.	TOTAL 2008 Rs.	CUMULATIVE 2007 Rs.
GENERAL CHARGES	3,201,134.34	3,623,399.29	6,732,275.34	3,343,978.41	817,469.38	2,142,623.55	2,683,718.95	3,070,676.63	618,554.22	3,209,128.16	24,442,958.27	22,609,403.30
SUPERINTENDENT & STAFF	3,445,031.39	3,446,412.86	4,610,137.70	2,406,155.32	792,156.60	1,544,825.49	794,745.05	2,708,587.11	496,064.18	2,006,319.17	22,250,434.87	23,718,294.13
UPKEEP	1,981,477.15	1,563,088.49	4,071,461.70	1,056,160.85	773,164.24	881,388.07	1,491,665.07	455,767.42	657,522.55		12,931,695.54	9,981,511.26
CUTIVATION	1,120,871.72	353,589.58	444,542.75	359,538.83	83,313.62	48,983.72	710,067.87	157,599.66	7,652.40		3,286,160.15	8,598,223.94
HARVESTING	1,232,326.00	799,972.63	1,153,163.61	797,370.71	154,299.79	370,669.45	541,166.21	914,790.10	27,966.90		5,991,725.40	4,770,104.01
TOTAL COST OF PRODUCT.	10,980,840.60	9,786,462.85	17,011,581.10	7,963,204.12	2,620,403.63	4,988,490.28	6,221,363.15	7,307,420.92	1,807,760.25	5,215,447.33	68,902,974.23	69,677,536.64
CURING INTO COPRA/DISPOSE	259,928.18	179,318.47	43,509.60	177,564.32	6,821.33	103,533.63	15,175.75	87,159.92	6,700.50		879,711.70	721,504.18
ANIMAL HUSBANDRY	415,237.05	512,349.38	375,429.15	166,783.12	222,197.75	963,125.09		202,418.51	138,281.54		2,995,821.59	2,754,491.47
TOTAL EXPENDITURE	11,656,005.83	10,478,130.70	17,430,519.85	8,307,551.56	2,849,422.71	6,055,149.00	6,236,538.90	7,596,999.35	1,952,742.29	5,215,447.33	72,778,507.52	73,153,532.29
SALES OF COPRA	769,732.00	95,827.58	39,710.00	181,897.45	8,118.50	5,220.00	4,510.00	63,264.00	31,906.50		1,200,186.03	2,170,403.22
SALES OF COCONUT	10,640,780.66	14,320,381.69	29,731,272.77	15,673,195.17	1,853,059.40	9,181,435.48	14,451,473.63	9,628,457.20	450,486.29		105,930,542.29	86,418,494.31
SALES OF SEEDLING		291,200.00	1,180,940.00		705,180.00	353,890.00	365,860.00	500.00	902,166.70	142,000.00	3,941,736.70	3,394,399.00
SALES OF SUNDRIES	717,317.32	47,745.92	118,337.02	333,327.86	168,251.46	226,701.77	56,023.10	276,841.76	157,698.62	7,760.00	2,110,004.83	1,996,309.39
SALE OF ANIMALS PRODUCE &	1,362,220.12	473,426.67	318,058.00	665,633.50	175,460.63	916,756.60		115,570.29	118,035.35	277.00	4,145,438.16	3,836,116.37
	13,490,050.10	15,228,581.86	31,388,317.79	16,854,053.98	2,910,069.99	10,684,003.85	14,877,866.73	10,084,633.25	1,660,293.46	150,037.00	117,327,908.01	97,815,722.29
STOCK VARIANCES	664,118.00	-274,536.00	550,855.00	1,103,824.50	123,852.00	-2,526,180.00	579,139.00	309,180.00	34,784.00	198,940.00	763,976.50	8,591,392.55
ADJUSTED INCOME	14,154,168.10	14,954,045.86	31,939,172.79	17,957,878.48	3,033,921.99	8,157,823.85	15,457,005.73	10,393,813.25	1,695,077.46	348,977.00	118,091,884.51	106,407,114.84
SURPLUS/(DEFICIT)	2,498,162.27	4,475,915.16	14,508,652.94	9,650,326.92	184,499.28	2,102,674.85	9,220,466.83	2,796,813.90	-257,664.83	-4,866,470.33	45,313,376.99	33,253,582.55
LESS - AMORTIZATION & DEPRI	393,497.14	433,368.71	854,113.47	416,345.33	107,236.84	237,292.45	404,851.46	259,660.96	150,542.46		3,256,908.82	3,143,230.49
NET SURPLUS/(DEFICIT)	2,104,665.13	4,042,546.45	13,654,539.47	9,233,981.59	77,262.44	1,865,382.40	8,815,615.37	2,537,152.94	-408,207.29	-4,866,470.33	42,056,468.17	30,110,352.06
TRANSFER TO HEAD OFFICE EXPENSES											5000000.00	5000000.00
											37,056,468.17	25110352.06